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LF RESOLVED COMPONENT INDICATOR VP 253.3

MP MASTER
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SOLARTRON

TECHNICAL MANUAL

MP MASTER
MA24440

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BRITISH AIRCRAFT CORPORATION, STEVENAGE.

INSTRUCTION MANUAL

FOR

L.F. RESOLVED COMPONENT INDICATOR

MODEL VP.253.3

PREFACE

Of recent years there has been an increased tendency to employ closed loop feedback control, this tendency being equally apparent in the fields of mechanical, electrical and electronic engineering. Whatever the field of application, the designer is, in almost every case, faced with the same basic problem, namely: that of providing the stiffest possible control over the working frequency range consistent with freedom from oscillation or under-damped response, outside the working frequency range. Such design work demands a full knowledge of the transfer function of each element employed in the control loop.

The usual method of transfer function determination is to excite the unit under test at a number of fixed frequencies covering the interested frequency range, using a constant input amplitude. The output amplitude and phase angle is noted in each instance, and these results are then recorded on polar co-ordinated paper to form what is now universally known as a Nyquist diagram. The Resolved Component Indicator is ideally suited to this method of measurement. Provision is made for two input voltages—one is known as the reference voltage, and the other as the signal voltage. Two 6-in. scale-length meters are provided, and the function of these is to separately indicate, in terms of true voltage, the resolved components of the signal input which are ' in phase with ' and ' at 90° to ' the reference input voltage. This resolved component presentation permits direct plotting of a Nyquist diagram on ordinary linear graph paper, thus eliminating the need for polar co-ordinate paper. A very important feature of the Resolved Component Indicator is that the meter indications are to a first order, independent of harmonic or spurious frequency content of the signal voltage, providing the reference voltage employed is itself free from such quantities.

There is scope for application of the Resolved Component Indicator wherever phase conscious measurement is required over the frequency range 0.05 c/s to 1 Kc/s, e.g., transformer testing, dynamic balancing, simulator circuits, magnetic core material comparison tests, etc.

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SECTION I

PERFORMANCE SPECIFICATION

General

This instrument will indicate, by means of two centre-zero 6-in. scale meters, the resolved components of a signal voltage with respect to the applied reference energisation.

Frequency Range (nominal)

0.05 c/s to 1 kc/s

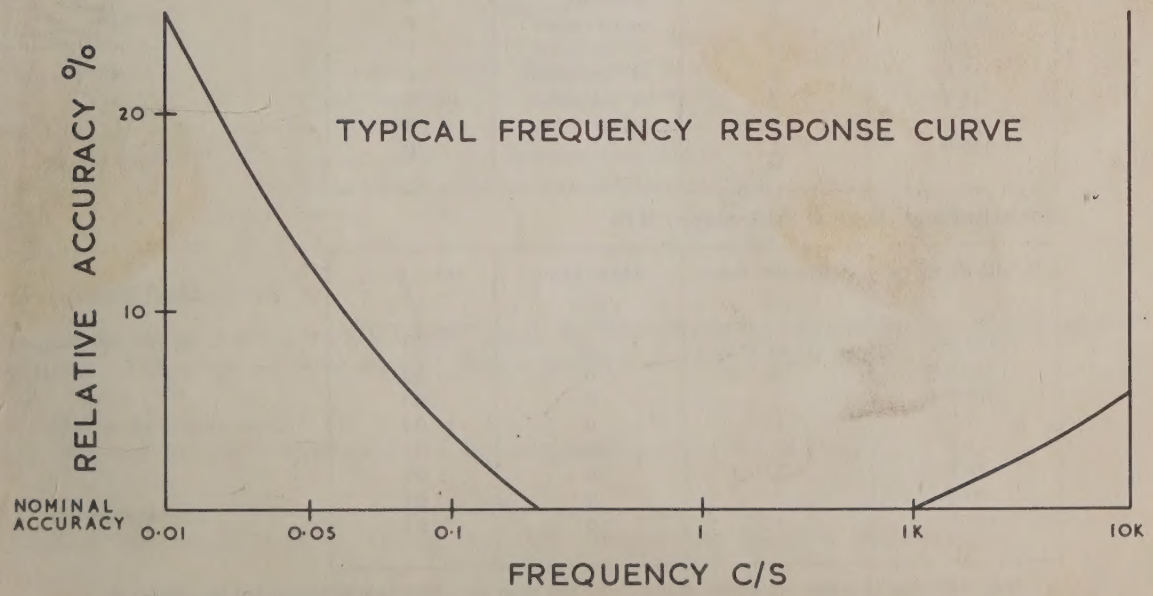
(A calibration chart indicating errors introduced between 1 kc/s and 10 kc/s can be supplied, if requested when ordering new equipment).

TYPICAL FREQUENCY RESPONSE CURVE

Sensitivity and Resolution

Mode	Sensitivity Range	Resolution %
Normal (Meter)	50 mV–150 V F.S.D. R.M.S.	1% of full scale
Scale expand X.1 (Digital Voltmeter)	1.5 Volts for F.S.D. on all meter ranges	.1% of full scale
Scale expand X.10 (Meter)	5 mV–15 V F.S.D. R.M.S.	1% of full scale
Scale expand X.10 (Digital Voltmeter)	Approx. .15 Volts for F.S.D. on all scale expand (Meter) ranges	.1% of full scale

(See Accuracy Chart)



ACCURACY (Reference and Quadrature Meters)

Normal (Meter)

Sensitivity Range	Attenuator Error ±%	Meter Error ±%	Other Error ±%
50 mV	Pre set 0	Accuracy of	0
150 mV	1	indication	0
500 mV	1	on all ranges	0
1.5 V	1	within ±1.5%	0
5 V	1	of summation	0
15 V	1	of end scale	0
50 V	2	values	0
150 V	2		0

Scale Expand XI (Digital Voltmeter)

Sensitivity Range	Attenuator Error ±%	Meter Error ±%	Other Error ±%
50 mV	Pre set 0	0	0.25
150 mV	1	0	0.25
500 mV	1	0	0.25
1.5 V	1	0	0.25
5 V	1	0	0.25
15 V	1	0	0.25
50 V	2	0	0.25
150 V	2	0	0.25

Scale Expand (Meter) X10

Sensitivity Range	Attenuator Error ±%	Meter Error ±%	Other Error* ±%
5 mV	Pre set 0	Accuracy of	0
150 mV	1	indication	0
500 mV	1	on all ranges	0
1.5 V	1	within ± 1.5%	0
5 V	1	of summation	0
15 V	1	of end scale	0
50 V	2	values	0
150 V	2		0

Scale Expand (Digital Voltmeter) X10

Sensitivity Range	Attenuator Error ±%	Meter Error ±%	Other Error ±%
50 mV	Pre set 0	0	0.1
150 mV	1	0	0.1
500 mV	1	0	0.1
1.5 V	1	0	0.1
5 V	1	0	0.1
15 V	1	0	0.1
50 V	2	0	0.1
150 V	2	0	0.1

* D.C. drift due to warm up, mains change, etc., less than 2%. This can be eliminated in setting up procedure.

Reference Input

Phase. 0°, 90°, 180°, 270°

Normally provided by Solartron Low Frequency Decade Oscillator OS.103.3 for electrical and electronic systems

OR

Solartron Mechanical Reference Generator JX. 603 .3 for systems where the input is other than electrical (mechanical, hydraulic, pneumatic, etc.).

Amplitude.

10 Volts R.M.S. for each phase

Input Impedance.

6.2mΩ per phase

C.R.O. Output Socket

6.5 Volts (nominal) for F.S.D. on normal mode. Output impedance less than 10kΩ.

Signal Input Mode

(i) 0° and 180° Balanced about mains earth
(ii) 0° and 180° Balanced about common (mains earth isolated)
(iii) 0° or 180° Unbalanced to mains earth
(iv) 0° or 180° Unbalanced to common

Signal Input Impedance

Unbalanced 10mΩ
Balanced 20mΩ

Harmonic and Noise Rejection

Mode	Rejection
Normal	Better than 40dB for related harmonics Better than 60dB for unrelated harmonics
Scale expand	As for normal but dynamic handling of related and unrelated harmonics improved 10 : 1

Overload Indication

Since the meters in the instrument respond only to the fundamental frequency of the input signal a visual overload indicator operates when signal + noise is greater than F.S.D. on any range.

Mains Requirements

90–130 V and 200–240 V 40/60 c/s with a total consumption of 215 V.A. (205 watts).

Presentation

Standard rack panel 19 in. × 12¼ in. high, but mounted in a 'Solartron' bench type case.

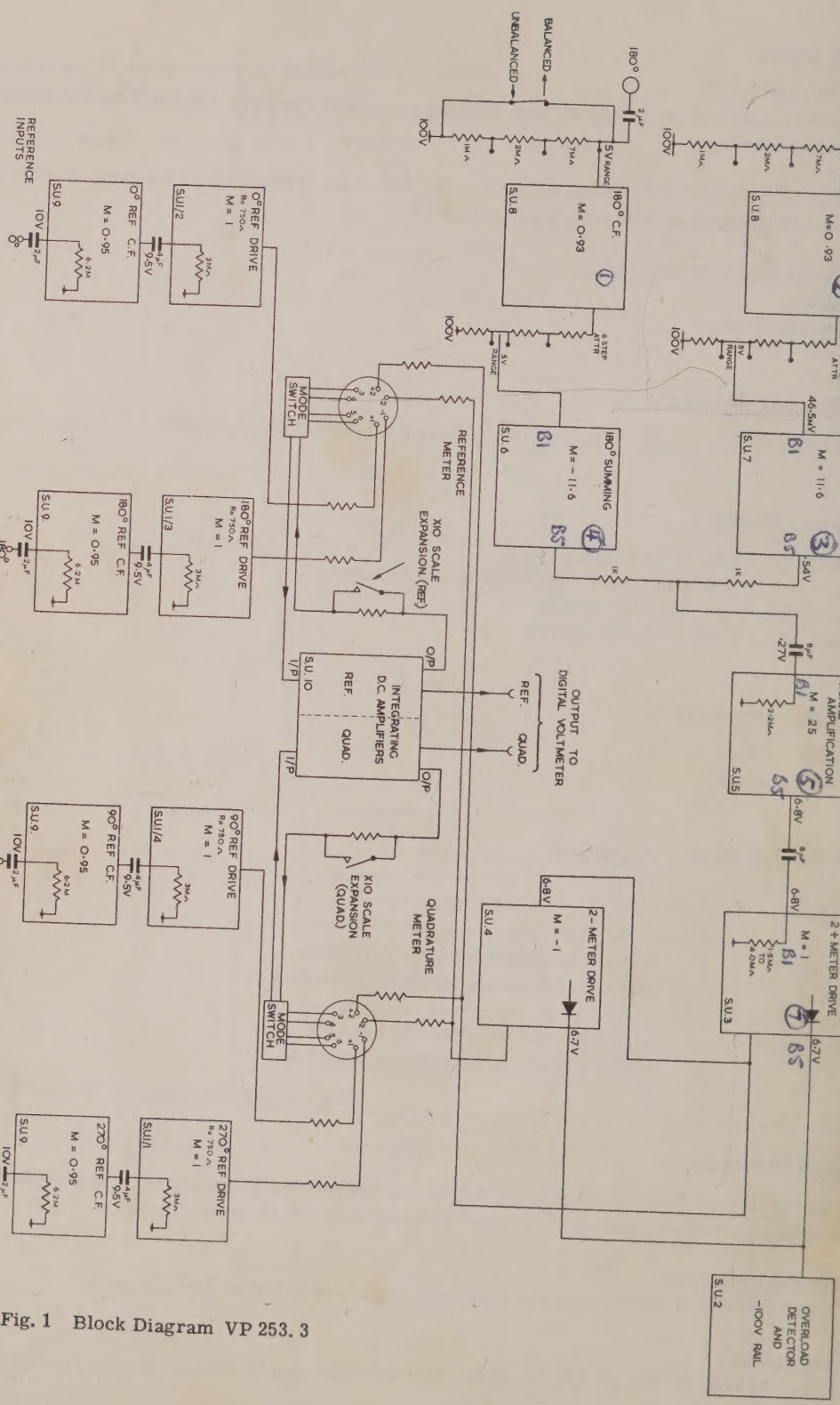


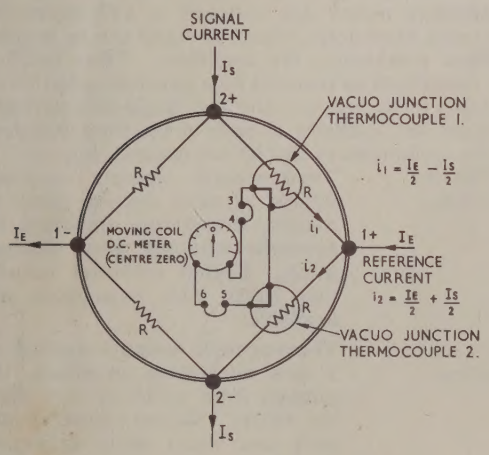
Fig. 1 Block Diagram VP 253. 3

SECTION 2

PRINCIPLES OF OPERATION

The Resolved Component Indicator displays the 'in phase' and 'quadrature' components of an A.C. signal with respect to a related reference voltage. The equipment comprises a series of signal amplifiers and reference amplifiers interconnected as shown in the block diagram (Fig. 1). These amplifiers drive two special bridge connected thermocouple meters, which are the phase-discriminating circuit elements.

The circuit of one of these meters is shown in Fig. 2.



A balanced reference voltage, either 'in phase' or 'quadrature,' drives the energising current through the meter, and a balanced signal voltage drives the signal current.* It can be shown that with this system, the meter indication is directly proportional to the component of the signal which is in phase with the reference voltage, case (*a*), Appendix A, and in the ideal case there is no indication from harmonics, case (*b*), spurious frequencies, or noise signals, case (*c*), which are not simultaneously present in the reference signal.

Referring again to Fig. 1, the balanced input signal passes through a matched pair of input attenuators to two cathode followers which drive further simple ladder attenuators. The outputs from the 0° and 180° attenuators then pass through a pair of amplifiers, the 0° having a gain of 11·6 and the 180° having a gain of — 11·6. The resultant amplified signals, which are in phase, are added in a pair of matched resistors to give common mode rejection. The summation signal is A.C. coupled into another stage of amplification which is succeeded by the meter drive and image meter drive amplifiers which supply signal current to both meters. When the meter drive signal exceeds a preset maximum, equivalent to $\sqrt{2} \times$ the in-phase signal to give full-scale deflection on the reference meter, an overload detector operates, indicating that the device is operating in a non-linear fashion.

When a single-ended signal is used, the balanced–unbalanced signal is switched to unbalanced and the 180° input is virtually short-circuited.

A four-phase reference signal is required, and each phase passes through a cathode follower which is A.C. coupled to a unity gain meter drive amplifier. The 0° and 180° phases drive the reference meter, and the 90° and 270° phases drive the quadrature meter.

There are three A.C. couplings in the signal channel which will give rise to some phase shifts at very low frequencies. To compensate for this, two A.C. couplings have been incorporated in each reference channel. This results in approximately equal phase shifts in the signal and reference channels, and negligible loss of accuracy down to 0·1 c/s.

SECTION 3

OPERATING INSTRUCTIONS

On receipt of the instrument, open the small door in the bottom rear corner of the right-hand side of the case. Extract two coaxial leads and one four-phase reference lead. Withdraw the mains cable as required, and insert it in the slot beside the door. Check that the mains selector panel is correctly set to the nominal supply voltage, close the door.

The unit requires a four-phase reference supply of 10 V r.m.s. per phase which is obtainable from either the Solartron L.F. Decade Oscillator Model OS.103.3 or the Solartron Mechanical Reference Generator Model JX.603. Connect this supply in correct phase sequence to the reference input terminals, or use the four-core cable provided.

When the Resolved Component Indicator has been placed in the position in which it is intended for use, the mechanical zero adjustments for the two meters should be correctly set before the instrument is switched on.

Switch on the instrument and allow approximately 10 minutes to warm up. Check the meter zero's on X.10 expansion and, if necessary, adjust the meter datum potentiometers. Connect the instrument to the signal to be measured, and select BALANCED or UNBALANCED as required.

It is recommended that one earth connection only be made from the work on test to the Resolved Component Indicator earth terminal, in order to eliminate the possibility of error voltages arising from loop currents. Further, when either the work, or any auxiliary equipment connected to the work, has a direct earth connection, the Resolved Component Indicator should be set to 47Ω earth. This connects a 47Ω resistor between the negative rail of the instrument and the mains earth, hence, eliminating once again a possibility of loop current. When the equipment connected to the Resolved Component Indicator is fully isolated, the above-mentioned switch should,

of course, be set for direct earth.

The choice of using either shielded or unshielded connecting wires will, in each case, be dependent upon the frequency, impedance and relative amplitude levels in the circuits supplying the Resolved Component Indicator. When operating at low level on high-impedance systems, it is essential that shielded cable be employed, otherwise pick-up signals in excess of the working signals may fully load the Resolved Component Indicator. On the other hand, if shielded cable is employed at high frequency the stray capacitance of the cable may well result in unwanted phase shift in the circuit under test. In every case, therefore, the above-mentioned points should receive careful consideration.

When shielded cable is employed, it is advised that the braiding be cut back at the free ends and a single earth wire be run from the Resolved Component Indicator earth terminal, thus protecting against loop currents.

When the signal to be measured is superimposed on a large quiescent voltage, the charging of the input time constant will paralyse the instrument for several minutes. To reduce this paralysis time to reasonable proportions, a PRIME position is provided on the sensitivity switch. This should be selected before switching to the required sensitivity range.

The drive amplifiers for the thermocouple wattmeters have overload protection which ensures that application of even the most excessive overload will not result in burn out. However, the instrument should not be left for more than 30 seconds with either indicating meter reading in excess of full scale, otherwise ageing of the thermocouple elements may result, with a consequent slight change in sensitivity.

Overload conditions may exist under conditions of poor signal-to-noise ratio or when both meters are operating near full scale in the presence of either harmonics or noise. Any overload, however short the duration, will be indicated by the overload neon, and steps should be taken to reduce the sensitivity range. The presence of an overload will adversely affect the accuracy of the instrument.

After a severe overload, the normal recovery time of the instrument is excessive. To reduce this, press the reset button and hold for a few seconds.

The wattmeters employed in the Resolved Component Indicator utilise thermocouple elements and, consequently, there will be a loss of sensitivity with increasing ambient temperature.

The extent of the sensitivity error is in the order of 0·2% per °C. The instruments are calibrated at a nominal room temperature of approximately 25°C and, consequently, operation at a temperature of 35°C will give an error in the order of 2%.

This temperature error applies only as far as absolute voltage measurement is concerned, and where transfer function is to be plotted its effect will be negligible. The usual procedure for testing is to apply a constant input voltage to the system under test, as determined by the oscillator output attenuator, and to plot at a number of suitably chosen frequencies the resolved components of the voltage present at the selected point in the test system. Providing that the input voltage for the work is maintained constant throughout the test, results may be directly plotted in Nyquist form, using cartesian co-ordinates.

The VP253.3 is provided with a reference and quadrature channel d. c. integrating amplifier for operation at very low frequencies (0.05 c/s - 1 c/s), and a x10 meter scale expansion for the resolution of small phase angles relative to 0°, 180° (quadrature meter on x10 expansion), or 90°, 270° (ref. meter on x10 expansion). Also when both reference and quadrature meters are switched to x10 expansion, ten times more noise relative to signal can be handled without overloading the amplifiers. These facilities are introduced as required by a panel-mounted three-position mode selector, and two single-pole switches. The services available in each of the three positions of the mode selector can be summarised thus :—

NORMAL position : Thermocouple outputs (response approx. 2 secs) applied direct to meters. Integrating amplifiers inoperative (chopper relays de-energised). Digital voltmeter outputs and meter scale expansions not available.

1 c/s - 1 kc/s position : Thermocouple outputs applied to 2 secs integrating amplifiers, the outputs from which in turn drive the meters. Digital voltmeter outputs and meter scale expansion available. Long time-constant (45 seconds) integrating circuit held operational ready for instant use if mode selector is set to the v. l. f. position (0.05 c/s - 1 c/s).

0.05 c/s - 1 c/s position : Thermocouple outputs applied to integrating amplifiers, the outputs from which in turn drive the meters. Digital voltmeter outputs and meter scale expansions available. Long time-constant (45 seconds) integrating circuits switched in.

In general, when operating at frequencies in excess of 1 c/s, and when meter scale expansion and digital voltmeter outputs are not required, the mode selector should be set to the NORMAL position to conserve the life of the chopper relays contacts.

The ± 2.8 volts output from the integrator is divided down to ± 1.5V for application to the digital voltmeter, so that this meter gives the correct reading for the 1.5V range of the VP253.3, and also the correct digital reading, ignoring the decimal point, for all decade ranges of 1.5V. When operating on the VP253.3 50mV, 5V, and 50V ranges, ignore decimal point and divide digital voltmeter reading by a factor of 3.

When using a digital voltmeter with very low frequency signals, its readings will change by the same amount as the beat ($\pm 8\%$ at 0.05 c/s) on the meter due to the double-frequency term. In the presence of high level noise the a.c. term outputs (cases (b) and (c), appendix A), can be reduced by switching in the 45 sec time-constant, which has the effect of

giving the instrument a very high frequency discrimination characteristic.

Measurement of Small Phase Angles

Switch both reference and quadrature meters to x10 expansion. Short VP253.3 inputs to common rail and adjust reference and quadrature datum potentiometers for zero reading. Set the reference (or quadrature meter) to x1, and connect input to 0° (or 90°) source of OS103.3, and set VP253.3 range switch for approximately f.s.d. on reference (or quadrature) meter. Adjust the phase of the OS103.3 with the concentric friction-loaded fine-frequency control for zero reading on the quadrature (or reference) meter, or note phase error introduced by OS103.3. Connect in system under investigation. If high phase angle resolution is required at large angles, then the —JX746 can be used to bring the quadrature meter down to zero (on x10) to enable it to be used as previously described. When using a digital voltmeter high resolution can be obtained at any angle, viz :—

Reference d.v.m. reading +1.000 } phase angle
Quadrature d.v.m. reading +1.000 } =45°
Reference d.v.m. reading +1.010 } phase angle
Quadrature d.v.m. reading +0.990 } =45.57°.

SECTION 4

CIRCUIT DESCRIPTION

The circuit is described in a number of sections corresponding to the various types of sub-unit comprising the complete equipment.
Each section will include a circuit description, component lists and circuit diagram of the sub-unit, together with a table of quiescent voltages and component identification photographs.
The method of obtaining access to the sub-units is described in Section 5.
The following abbreviations and notes are applicable to the component lists.

(1) Notes:—
Blank spaces indicate no change from the preceding line.
In some instances, direct equivalents from other manufacturers may be used.

(2) Abbreviations:—

H.S.	High stability.
W.W.	Wire wound.
M.P.	Metallised paper.
Ce	Ceramic.
M.S.M.	Moulded silvered mica.
T.C.C.	Telegraph Condenser Co.
G.E.C.	General Electric Co.
S.T.C.	Standard Telephones and Cables.

The tables of quiescent voltages are typical values given as a guide to servicing. The most satisfactory method of checking them is to use an extension lead with nine-way micronector plug at one end and socket at the other. They are measured with respect to earth, with no input signals and the range selector to PRIME.

4.1. SUB-UNIT 1

Sub-unit 1 is the reference amplifier and occurs four times, once in each phase of the reference signal. It is a negative feedback amplifier, of approximately unity gain, operating as a broad band impedance transformer with a high signal current output.
The reference signal from the cathode follower in sub-unit 9 is capacitor-coupled to the signal input pin (B1) on plug A, B, C or D. This is connected through the grid stopper R3 into the grid of V1A, the first amplifying valve. Output from the anode of V1A is divided down in R5 and R6 and coupled through grid stopper R7 to the grid of V1B, the second amplifying valve. The output from V1B is divided down in R10 and R11 and coupled through the grid stopper R12 into the grid of V2, the output cathode follower. 100% negative feedback is obtained by directly coupling the cathodes of V1A and V2. The grid of V1A is returned through R1 to a negative potential adjustable by RV1. The cathode of V1B is referred to earth potential through pin (A3) on the input plug. C1 and C3 are provided to correct phase shifts at the higher operating frequencies, and C2, R9 prevents excessive phase shifts and consequent oscillation at frequencies above the maximum operating frequency.

Plug connections are as follows:—

A1	6·3 V A.C.	B1	Signal Input
A2	6·3 V A.C.	B2	—
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	—
		B5	Signal Output

Quiescent Potentials

Valve No.	Pin No.	Meter Reading	Meter Range
V1	1	100 V	250 V
	6	105 V	250 V
	7	—1·2 V	2·5 V
Junction RV1 and R2		—1 V	2·5 V

Table 1.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.	
R1	3M	1	Painton	73 H.S.	¼	1707	63000
R2	220k	1			¼	1707	52200
R3	100	10	Erie	9 Carbon	¼	1723	21000
R4	220k	1	Painton	73 H.S.	¼	1707	52200
R5	560k	1			¼	1707	55600
R6	560k	1			¼	1707	55600
R7	100	10	Erie	9 Carbon	¼	1723	21000
R8	270k	1	Painton	73 H.S.	¼	1707	52700
R9	1000	10	Erie	9 Carbon	¼	1723	31000
R10	1·6M	1	Painton	73 H.S.	¼	1707	61600
R11	1M	1			¼	1707	61000
R12	100	10	Erie	9 Carbon	¼	1723	21000
R13	220	10			¼	1723	22200
R14	22	10			¼	1723	12200
R15	5100	1	Painton	P406 W.W.	3	1736	35100
R16	750	1	Erie	109 H.S.	¼	1704	27500
RV1	5000	10	Colvern	CLR1206/9S W.W.	¼	1100	26090

Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.	
C1	10	10	Erie	P100K Ce	500	2401	11000
C2	68	10	T.C.C.	CSM20N M.S.M.	350	2502	16800
C3	18	10	Erie	P100L Ce	500	2401	11800

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.	
V1	12AX7	Double Triode	S.T.C.	3000	33040
V2	A2134	Pentode	G.E.C.	3000	05110
PLA-D	MP9	Plug micronector 9-way	McMurdo		

NOTES
1. ALL CAPACITOR VALUES GIVEN IN MICRO-FARADS UNLESS OTHERWISE STATED.

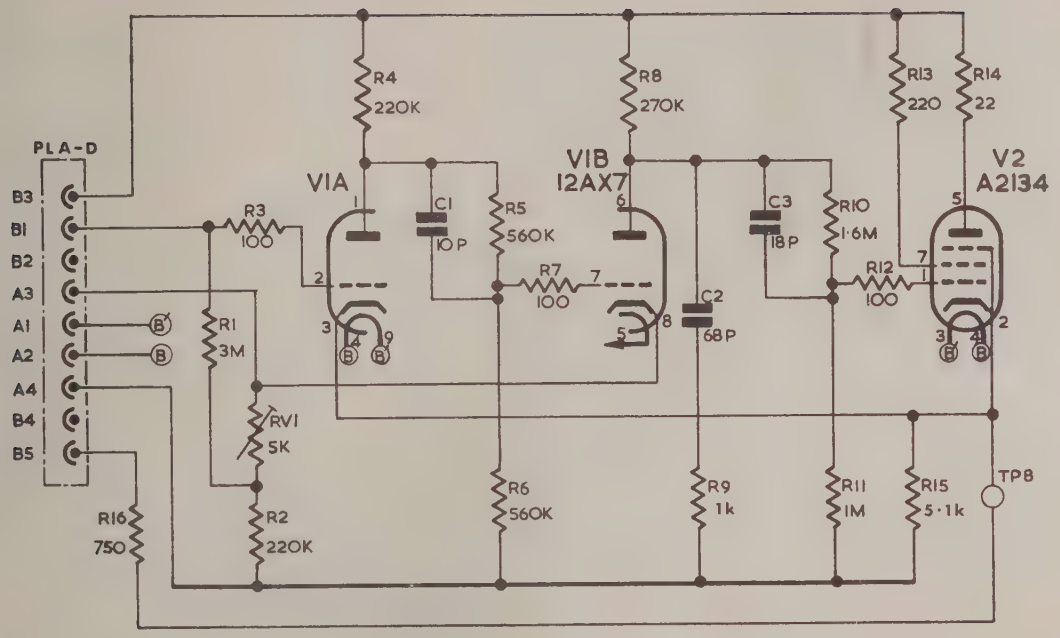


FIG. 3

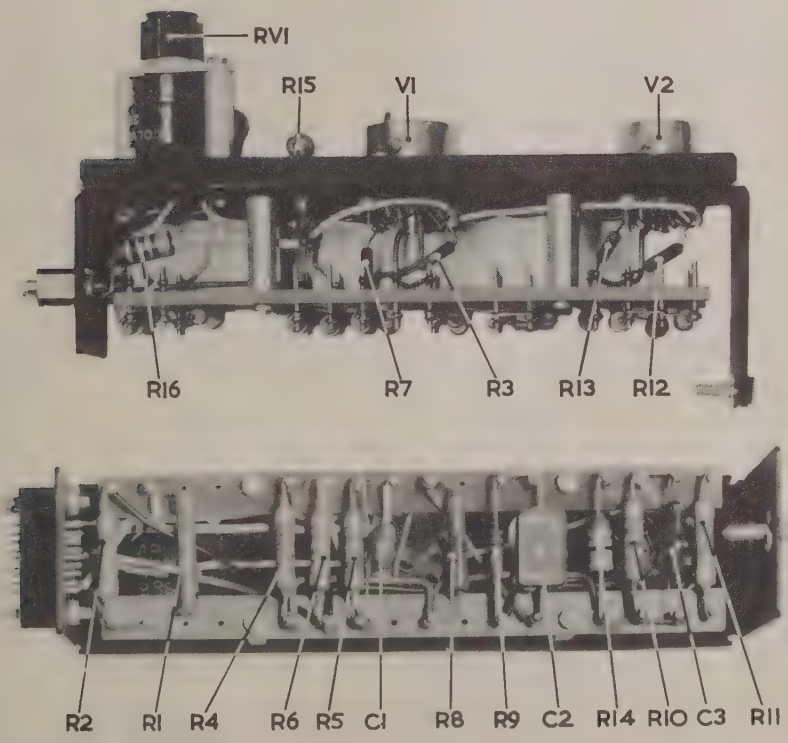


Plate 1: Sub-Unit 1

4.2. SUB-UNIT 2

Sub-unit 2 contains two functional circuits, the overload indicator and the — 100 V rail.

The balanced meter drive signal from the meter drive amplifier (sub-unit 3) and the image meter drive amplifier (sub-unit 4) is full-wave rectified to supply a positive-going signal to the grid of V11.

V11 is a cathode coupled bi-stable circuit in which the signal grid (pin 2) is returned to earth through R22 while the other grid (pin 7) is held at a preset positive voltage by the current through R24, R28, R29, RV11. When the positive-going peaks of the rectified sine waves exceed the predetermined overload signal, preset by RV11, the bi-stable circuit will change state, energising relay RLA/2. This connects the overload indicator across the heater A A by closing contact RLA.2. At the same time, contact RLA.1 opens and capacitor C95 (connected externally to pin B2 of PLE) commences to charge through R30. This raises the potential of the grid (pin 2) of V12, and when this passes the cathode potential, V12 will commence to conduct so that the potential of pin 7 of V11 rises.

The bi-stable circuit V11 will then reset and RL1 will open. If the overload has not been cleared, the sequence will immediately repeat. The resetting time constant of the circuit is approximately two seconds.

The other half of V12 together with both halves of V13 form a D.C. coupled negative feedback amplifier which establishes the earth line 100 V above H.T. negative. The input grid, pin 7 of V13B, is referred to a potential determined by R35, R36, R37 and RV12, the variable element being provided so that precise adjustment of the potential may be achieved. This grid is decoupled against hum and noise by C94 connected externally to pin B4 of PLE. The anode potential of V13B is D.C. coupled through the divider chain R40, R41 into the grid of V13A, and the anode potential of V13A is D.C. coupled through the divider chain R46, R47 into the grid (pin 7) of the cathode follower V12. Both cathodes of V13 and the cathode, pin 8, of V12 are coupled together giving positive feedback from V12 to V13A, and overall negative feedback from the cathode of V12 to V13B.

Any variation of current into or out of the earth line will result in a tendency to change the potential from earth to H.T. negative. This change will provide an error signal between the grid and cathode of V13B, which will be amplified and will control the current of V12 to compensate for the intial change. Thus a stable low impedance earth line is developed. C11 and 13 are to compensate for phase lags in the interstage couplings and C12, R45 is a phase correction network to prevent high-frequency parasitic oscillation.

Plug connections are as follows:—

A1	6·3 V A.C.	B1	Signal Input
A2	6·3 V A.C.	B2	'RESET' Time Constant
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	Decoupling Capacitor
		B5	Overload neon

Quiescent Potentials

Valve No.	Pin No.	Meter Reading	Meter Range
V11	1	193 V	250 V
	3	18·3 V	25 V
V12	7	—2 V	2·5 V
V13	1	100 V	250 V
	2	—1·1 V	2·5 V
	6	100 V	250 V
	7	—1·1 V	2·5 V

Table 2.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.	
R21			Not fitted			—	—
R22	1M	10	Erie	9 Carbon	¼	1723	61000
R23	100	10			¼	1723	21000
R24	10k	10		8	¼	1725	41000
R25	10k	5	Welwyn	F5 M F.	3	1930	41000
R26	22	10	Erie	9 Carbon	¼	1723	12200
R27	100	10			¼	1723	21000
R28	180k	1	Painton	73 H.S.	¼	1707	51800
R29	120k	1			¼	1707	51200
R30	2·2M	10	Erie	9 Carbon	¼	1723	62200
R31	100	10			¼	1723	21000
R32	22	10			¼	1723	12200
R33	22	10			¼	1723	12200
R34	100	10			¼	1723	21000
R35	4·7M	10			¼	1723	64700
R36	220k	1	Painton	73 H.S.	¼	1707	52200
R37	100k	1			¼	1707	51000
R38	100	10	Erie	9 Carbon	¼	1723	21000
R39	220k	1	Painton	73 H.S.	¼	1707	52200
R40	560k	1			¼	1707	55600
R41	560k	1			¼	1707	55600
R42	100	10	Erie	9 Carbon	¼	1723	21000
R43	33k	2	Welwyn	Welmet M.F.	1	1964	43300
R44	220k	1	Painton	73 H.S.	¼	1707	52200
R45	1000	10	Erie	9 Carbon	¼	1723	31000
R46	560k	1	Painton	73 H.S.	¼	1707	55600
R47	560k	1			¼	1707	55600
RV11	25k	20	Morganite	LH Carbon	¼	1100	07070
RV12	5000	10	Colvern	CLR1206/9S W.W.	¼	1100	26090

Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.	
C11	150	10	T.C.C.	CSM20N M.S.M.	350	2502	21500
C12	150	10			350	2502	21500
C13	22	10	Erie	P100L Ce	500	2401	12200
C14	25	20	Hunt	AM109 MPI	350	2082	00005

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.	
V11	12AT7	Double Triode	S.T.C.	3000	33020
V12	12AT7			3000	33020
V13	12AX7			3000	33040
PLE	MP9	Plug Micronector 9-way	McMurdo		
RLA	4193BA	Relay	S.T.C.	3006	50070

C14 ON CIRCUIT 4 IN TEST SET IS 0·25μf 350V WKG HUNTS AM109

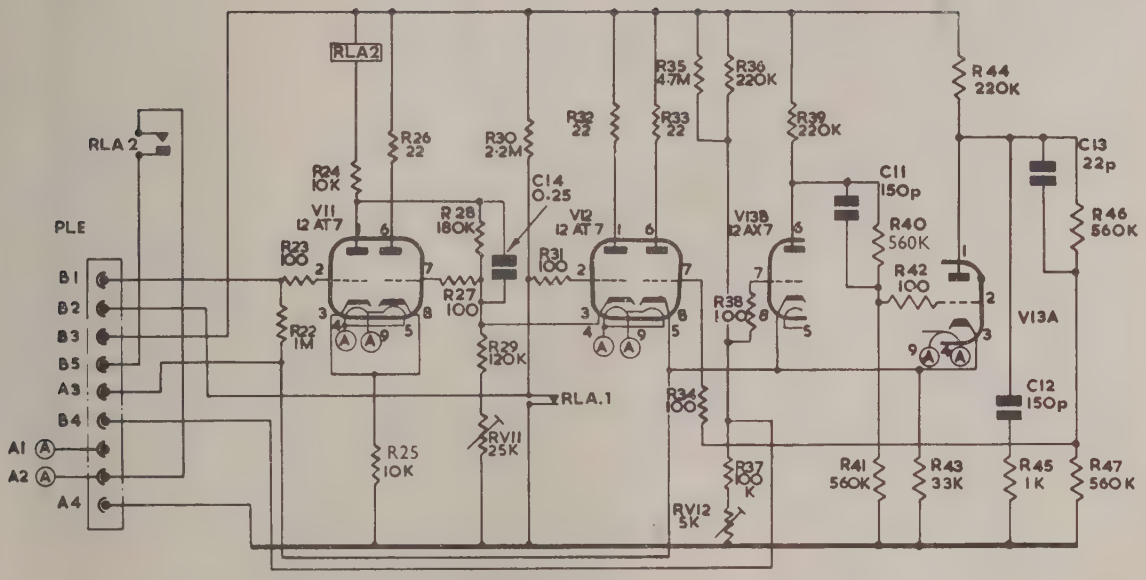
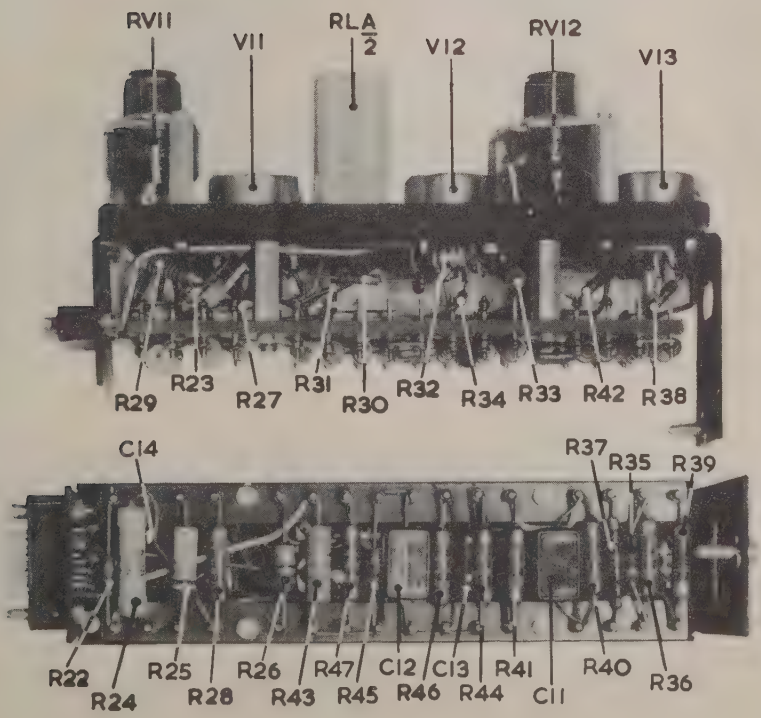

RLA2
RLA 2
PLE
B1
B2
B3
B5
A3
B4
A1
A2
A4
R24 10K
R26 22
R30 2·2M
R32 22
R33 22
R35 4·7M
R36 220K
R39 220K
R44 220K
C13 22p
C11 150p
R40 560K
R46 560K
R42 100
V13A
C12 150p
R23 100
R22 1M
R28 180K
C14 0·25
R27 100
R29 120K
R31 100
R38 100
R34 100
RLA.1
RV11 25K
R25 10K
R37 100 K
RV12 5K
R41 560K
R43 33K
R45 1K
R47 560K
V11 12 AT7
V12 12 AT7
V13B 12 AX7

FIG. 4.


RV11
V11
RLA 2
V12
RV12
V13
R29
R23
R27
R31
R30
R32
R34
R33
R42
R38
C14
R37
R35
R39
R22
R24
R25
R28
R26
R43
R47
R45
C12
R46
C13
R44
R41
C11
R40
R36

4.3. SUB-UNIT 3

This sub-unit contains a unity gain negative feedback amplifier consisting of three valves.

V21A is one-half of a double-triode type 12AX7 which receives its input through the grid stopper R63. The output of V21A is D.C. coupled through the divider chain R65, R66, to the grid of V21B, the second amplifying stage.

The output from V21B is D.C. coupled through R70 and R71 into the grid of the cathode follower V22 an A2134. Negative feedback is taken from the cathode of V22 to the cathode of V21A.

RV22 adjusts the voltage to which the grid of V21A is returned and sets up the D.C. conditions of the amplifier. RV21 varies the low-frequency transmission characteristics of the amplifier and is used to balance the low-frequency phase shifts in the signal and reference channels. C21 and C23 provide H.F. coupling between stages to reduce phase errors at the highest frequencies of operation.

C22, R69 is a phase-shaping network designed to prevent H.F. instability.

MR1 is a half-wave rectifier which feeds signals to the overload detector (Sub-unit 2).

Plug connections are as follows:—

A1	6·3 V A.C.	B1	Signal Input
A2	6·3 V A.C.	B2	—
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	Rectified Signal Output
		B5	Signal Output

Quiescent Potentials

Valve No.	Pin No.	Meter Reading	Meter Range
V21	1	100 V	250 V
	6	120 V	250 V
	7	—1·5 V	2·5 V
V22	1	—17 V	25 V
Junction RV21 and RV22		—1·3 V	2·5 V

Table 3.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.
R61	1·5M	2	Painton	73 H.S.	¼	1707 61500
R62	220k	1			¼	1707 52200
R63	100	10	Erie	9 Carbon	¼	1723 21000
R64	270k	1	Painton	73 H.S.	¼	1707 52700
R65	560k	1			¼	1707 55600
R66	560k	1			¼	1707 55600
R67	100	10	Erie	9 Carbon	¼	1723 21000
R68	270k	1	Painton	73 H.S.	¼	1707 52700
R69	1000	10	Erie	9 Carbon	¼	1723 31000
R70	1·6M	1	Painton	73 H.S.	¼	1707 61600
R71	1M	1			¼	1707 61000
R72	100	10	Erie	9 Carbon	¼	1723 21000
R73	220	10			¼	1723 22000
R74	22	10			¼	1723 12200
R75	3600	1	Painton	P306 W.W.	3	1736 33600
RV21	2·5M	20	Morganite	LH Carbon	½	1100 07130
RV22	5000	10	Colvern	CLR1206/9S W.W.	½	1100 26090

Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C21	33	10	Erie	N150L Ce	500	2084 00001
C22	68	10	T.C.C.	CSM20N M.S.M.	350	2502 16800
C23	6·8	·25pf	Erie	P100K Ce	500	2400 06800

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
V21	12AX7	Double Triode	S.T.C.	3000 33040
V22	A2134	Pentode	G.E.C.	3000 05110
MR1	GEX35	Germanium Diode	G.E.C.	3005 20230
PLF	MP9	Plug Micronector 9-way	McMurdo	

NOTES
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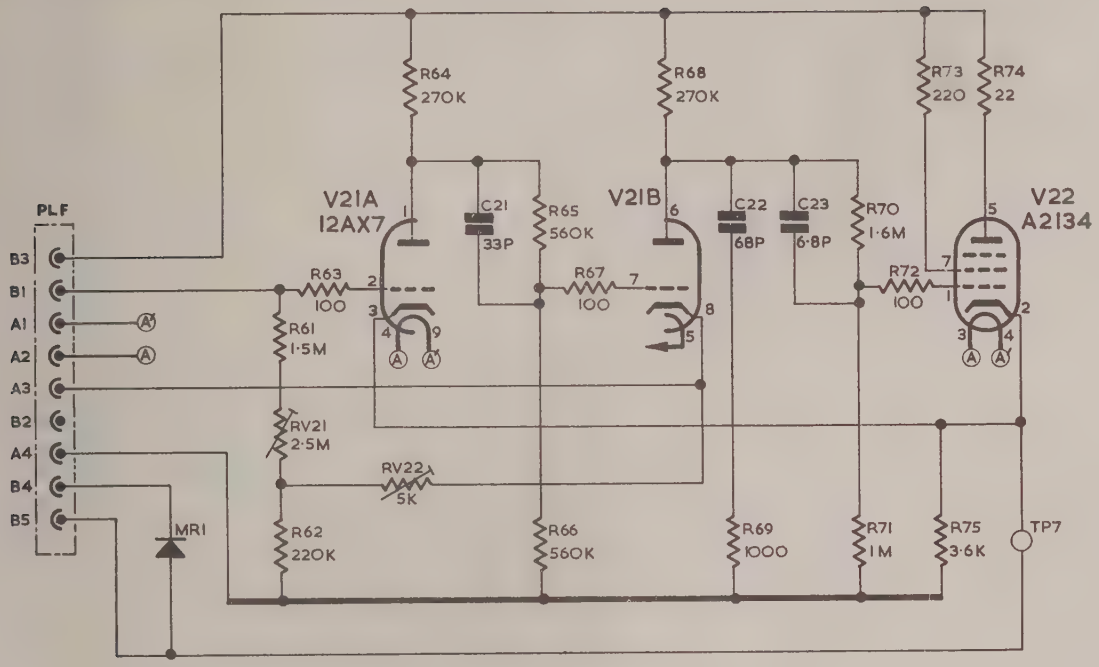
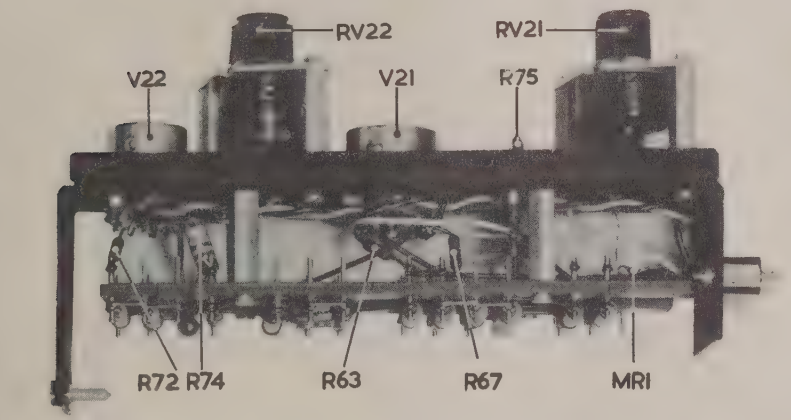


FIG. 5



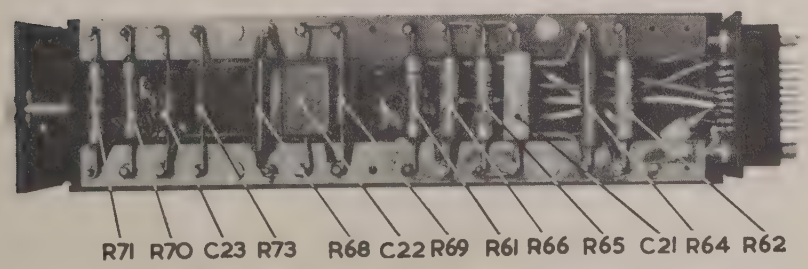


Plate 3: Sub-Unit 3

4.4. SUB-UNIT 4

Sub-unit 4 contains a unity gain image amplifier which together with sub-unit 3 provides balanced signal drive to the thermocouple meters. The input and output signals are added in R81, R84 to provide a difference signal which is fed into the input grid (pin 7) of V31.

V31 is a cathode coupled amplifier, the first half acting as a cathode follower coupling signal into the cathode of the second half. Amplified signal from the output of V31 is D.C. coupled through the divider chain R90, R92, into the grid (pin 7) of V32. The amplified output of V32 is D.C. coupled into the grid of the cathode follower V33, through the divider chain R94, R95.

Negative feedback signal from the output is balanced against the input signal in the see-saw resistors R81, R84. C31, C32, C34 and C35 provide H.F. coupling between stages to reduce phase errors at the highest frequencies of operation. C33, R89 is a phase-shaping network designed to prevent H.F. instability. The second half of V32 is connected as a diode and feeds signal to the overload detector (Sub-unit 2).

Plug connections are as follows:—

A1	6·3 V A.C.	B1	Signal Input
A2	6·3 V A.C.	B2	—
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	Rectified Signal Output
		B5	Signal Output

Quiescent Potentials

Valve No.	Pin No.	Meter Reading	Meter Range
V31	1	100 V	250 V
	2	1 V	2·5 V
	3	1·7 V	2·5 V
V32	6	122 V	250 V
	7	—1·5 V	2·5 V
V33	1	—15 V	25 V

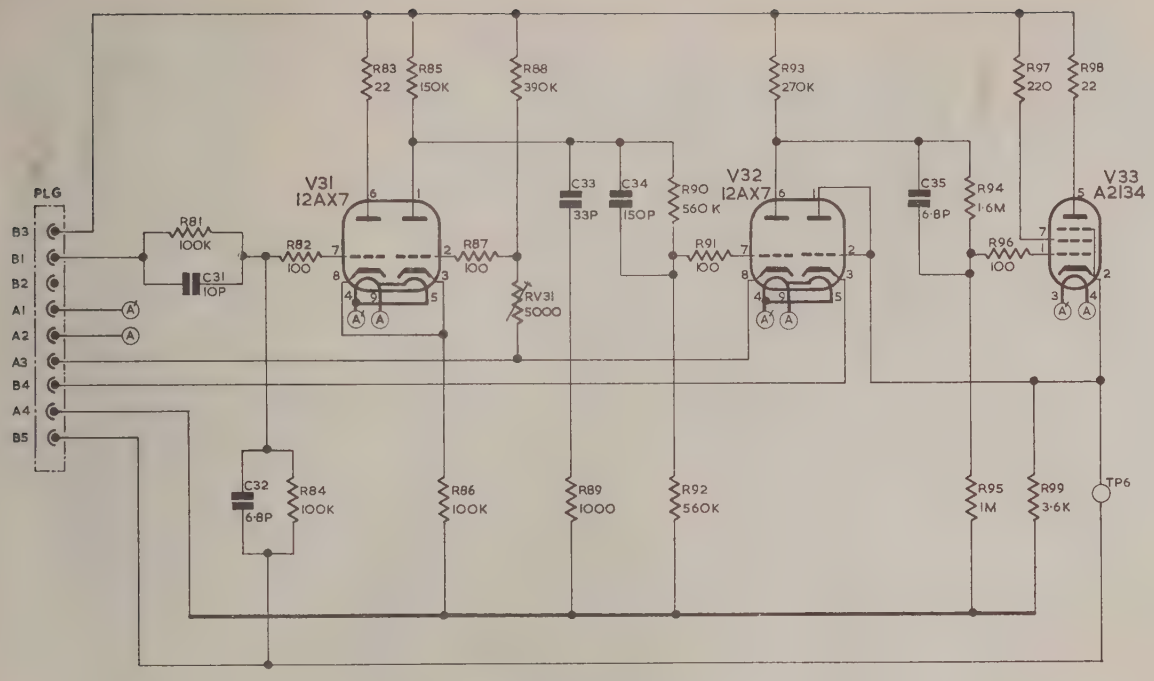
Table 4.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.
R81	100k	1	Painton	73 H.S.	½	1707 51000
R82	100	10	Erie	9 Carbon	¼	1723 21000
R83	22	10			¼	1723 12200
R84	100k	1		109 H.S.	¼	1704 51000
R85	150k	1	Painton	73	½	1707 51500
R86	100k	1			½	1707 51000
R87	100	10	Erie	9 Carbon	¼	1723 21000
R88	390k	1	Painton	73 H.S.	½	1707 53900
R89	1000	10	Erie	9 Carbon	¼	1723 31000
R90	560k	1	Painton	73 H.S.	½	1707 55600
R91	100	10	Erie	9 Carbon	¼	1723 21000
R92	560k	1	Painton	73 H.S.	½	1707 55600
R93	270k	1			½	1707 52700
R94	1·6M	1			½	1707 61600
R95	1M	1			½	1707 61000
R96	100	10	Erie	9 Carbon	¼	1723 21000
R97	220	10			¼	1723 22200
R98	22	10			¼	1723 12200
R99	3600	1	Painton	P306 W.W.	3	1736 33600
RV31	5000	10	Colvern	CL1206/9S W.W.	½	1100 26090

Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C31	10	10	Erie	P100K Ce	500	2401 11000
C32	6·8	·25pf			500	2400 06800
C33	33	10		N150L	500	2084 00001
C34	150	10	T.C.C.	CSM20N M.S.M.	350	2502 21500
C35	6·8	·25pf	Erie	P100K Ce	500	2400 06800

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
V31	12AX7	Double Triode	S.T.C.	3000 33040
V32	12AX7			3000 33040
V33	A2134	Pentode	G.E.C.	3000 05110
PLG	MP9	Plug Micronector 9-way	McMurdo	



NOTES

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FIG. 6

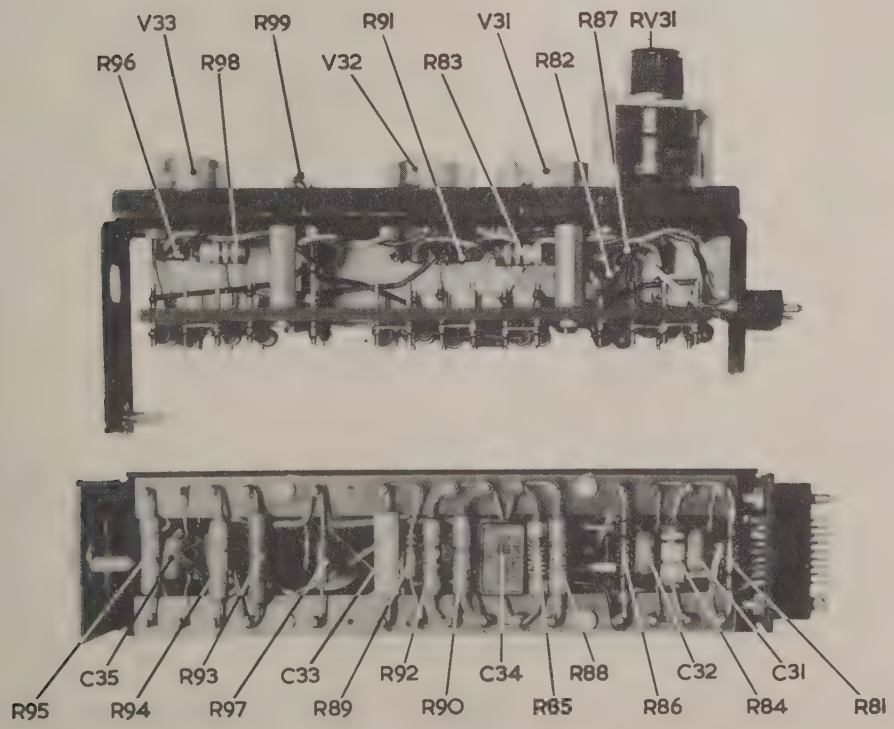

Plate 4: Sub-Unit 4

4.5. SUB-UNIT 5

Sub-unit 5 is the main signal amplifier and has a gain of about 25. It is a negative feedback amplifier, having two stages of gain in cascade followed by a cathode follower. Negative feedback is taken from the output cathode to the cathode of the first amplifier. Input signal from pin B1 of plug PLH is connected through the grid stopper R102 into the grid of the first amplifier V41A, one-half of a 12AX7. This grid is returned to earth through the grid leak R101. Cathode current through R105, RV41 is used to give the required bias and RV41 is adjusted for zero D.C. at test point 5. The output of V41A is D.C. coupled into the grid of the second amplifier V41B through the divide down network comprising R108, R109.

The output from the second amplifier is D.C. coupled through the divide down network R112, R113 into the grid of the cathode follower V42, one-half of a 12AX7. (The second half of this valve is not used.)

R117 is the cathode load, and negative feedback is taken from the output point to the cathode of V41A through the negative feedback attenuator comprising R115, RV42, R103. RV42 is provided to accurately preset the overall gain of the amplifier. R107 forms the D.C. current path for V41A current. C42 and C43 are H.F. coupling capacitors provided to minimise phase shifts at the higher frequencies of operation and C41, R104 form a phase-shaping network to prevent H.F. instability.

Plug connections are as follows:—

A1	6·3 V A.C.	B1	Signal Input
A2	6·3 V A.C.	B2	—
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	—
		B5	Signal Output

Quiescent Potentials

Valve No.	Pin No.	Meter Reading	Meter Range
V41	1	100 V	250 V
	3	1 V	2·5 V
	6	98 V	100 V
	7	—1 V	2·5 V
V42	7	—2 V	2·5 V

Table 5.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.	
R101	2·2M	1	Dubilier	417 H.S.	½	1707	62200
R102	100	10	Erie	9 Carbon	¼	1723	21000
R103	1800	1	Painton	73 H.S.	½	1707	31800
R104	10k	10	Erie	9 Carbon	¼	1723	41000
R105	1800	2	Painton	73 H.S.	½	1708	33900
R106	220k	1			½	1707	52200
R107	330k	10	Erie	9 Carbon	¼	1723	53300
R108	560k	1	Painton	73 H.S.	½	1707	55600
R109	560k	1			½	1707	55600
R110	100	10	Erie	9 Carbon	¼	1723	21000
R111	220k	1	Painton	73 H.S.	½	1707	52200
R112	560k	1			½	1707	55600
R113	560k	1			½	1707	55600
R114	100	10	Erie	9 Carbon	¼	1723	21000
R115	39k	1	Painton	73 H.S.	½	1707	43900
R116	22	10	Erie	9 Carbon	¼	1723	12200
R117	82k	1	Painton	73 H.S.	½	1707	48200
RV41	2500	10	Colvern	CLR1206/9S W.W.	½	1100	26090
RV42	10k	10	Colvern	CLR1206/9S W.W.	½	1100	26100

Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.	
C41	220	10	T.C.C.	CSM20N M.S.M.	350	2502	22200
C42	150	10			350	2502	21500
C43	10	10	Erie	P100K Ce	500	2401	11000

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.	
V41	12AX7	Double Triode	S.T.C.	3000	33040
V42	12AX7			3000	33040
PLH	MP9	Plug Micronector 9-way McMurdo			

NOTES
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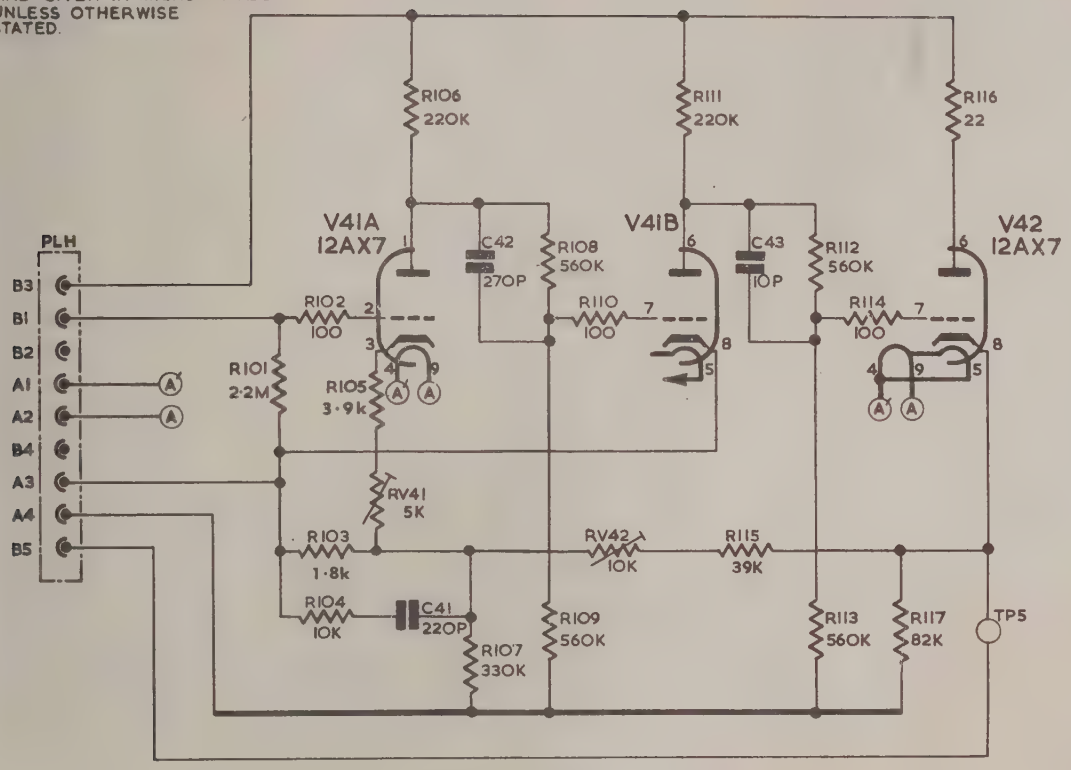


FIG.7

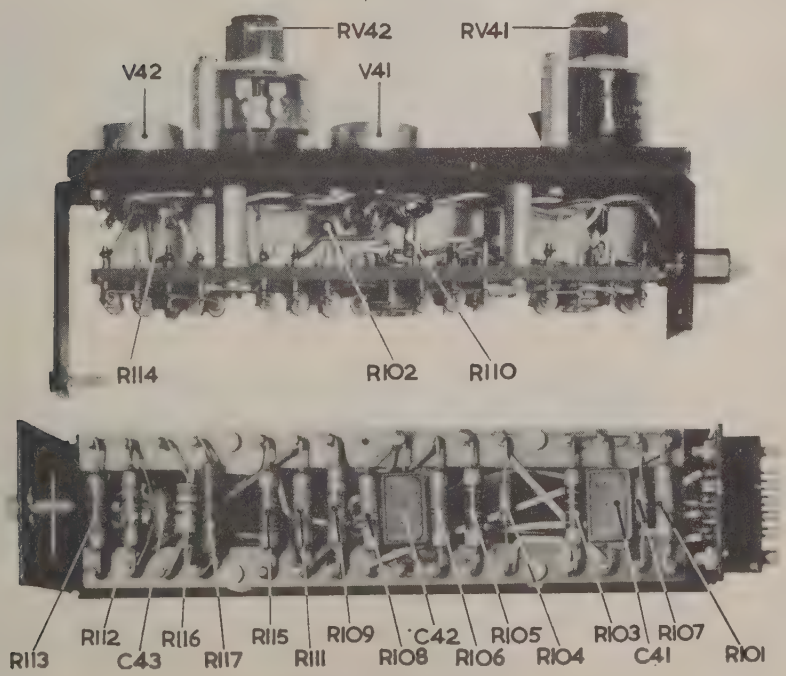


Plate 5: Sub-Unit 5

4.6. SUB-UNIT 6

Sub-unit 6 houses the 180° amplifier and the common mode rejection imaging amplifier.

Input signal from pin B1 of plug PLJ is connected through the grid stopper R121 directly into the grid of the triode connected low-noise pentode input amplifier V51. Cathode current bias for this stage is developed across R126 and RV51 which adjust D.C. levels to give zero quiescent output at test point 4.

The output of V51 is directly coupled to the grid of V52A, the second amplifier through the divide down chain R127, R128. The output from V52A is divided down in R131, R132 into the grid of the cathode follower V52B. Negative feedback is taken from the cathode of V52B through the gain determining negative feedback attenuator R134, R122, R123 to the cathode of V51.

C51 and C52 are provided to give phase correction at the higher operational frequencies.

The output from the cathode follower is connected through R137 into the input grid, pin 2, of V53. This stage is an amplifier and cathode follower employing negative feedback from the output to the input grid through R140, R141. The object of this unity gain stage is to reverse the 180° phase before adding it to the 0° phase. The 180° adding resistors are R148, and RV52 which is adjusted for maximum common mode rejection. C53 and C54 are provided to give phase correction at the higher operational frequencies.

Plug connections are as follows:—

A1	6·3 V A.C.	B1	Signal Input
A2	6·3 V A.C.	B2	—
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	—
		B5	Signal Output

Quiescent Potentials

Valve No.	Pin No.	Meter Reading	Meter Range
V51	1 & 6	100 V	250 V
	3 & 8	2·2 V	2·5 V
V52	1	89 V	100 V
	2	−0·9 V	2·5 V
	8	−4·3 V	10 V
V53	1	99 V	250 V
	2	−3 V	10 V
	7	−2 V	2·5 V

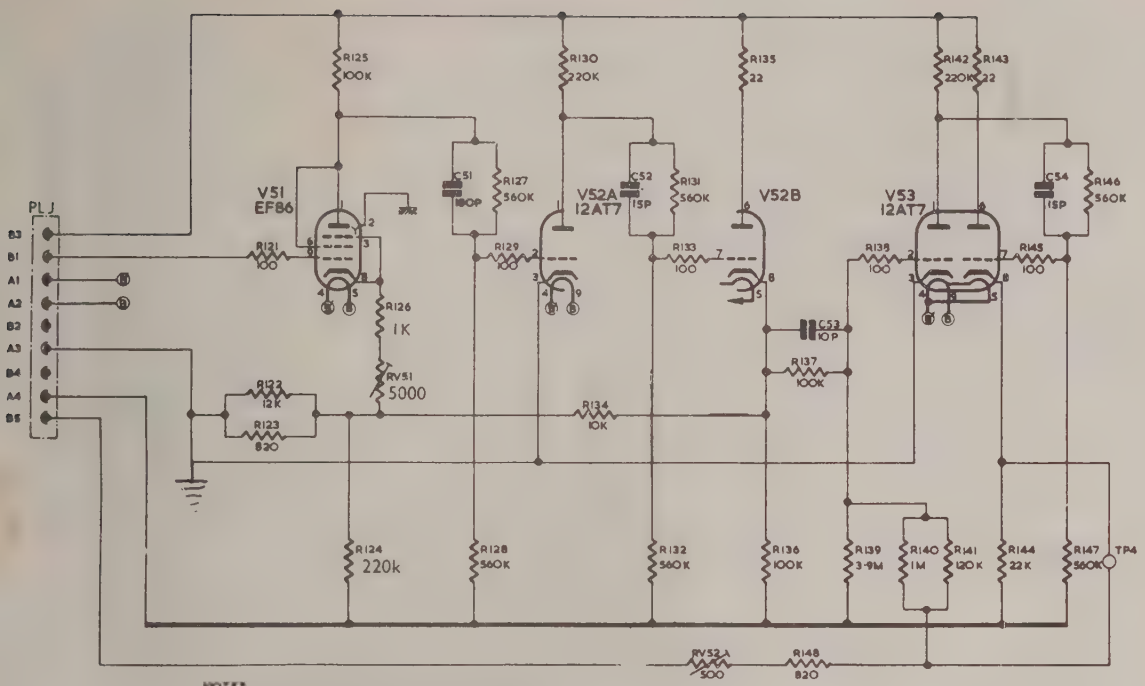
Table 6.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.
R121	100	10	Erie	9 Carbon	¼	1723 21000
R122	12k	10			½	1723 41200
R123	820	1	Painton	73 H.S.	¼	1707 28200
R124	220k	10	Erie	9 Carbon	¼	1723 52200
R125	100k	1		109 H.S.	¼	1704 51000
R126	1600	1	Painton	73	¼	1707 31000
R127	560k	1			¼	1707 55600
R128	560k	1			¼	1707 55600
R129	100	10	Erie	9 Carbon	¼	1704 21000
R130	220k	1		109 H.S.	¼	1704 52200
R131	560k	1	Painton	73	¼	1707 55600
R132	560k	1			¼	1707 55600
R133	100	10	Erie	9 Carbon	¼	1723 21000
R134	10k	1	Painton	73 H.S.	¼	1707 41000
R135	22	10	Erie	9 Carbon	¼	1723 12200
R136	100k	2	Welwyn	Welmet M.F.	1	1964 51000
R137	100k	1	Painton	73 H.S.	¼	1707 51000
R138	100	10	Erie	9 Carbon	¼	1723 21000
R139	3·9M	10			¼	1723 63900
R140	1M	10			¼	1723 61000
R141	120k	1	Painton	73 H.S.	¼	1707 51200
R142	220k	1	Erie	109	¼	1704 52200
R143	22	10		9 Carbon	¼	1723 12200
R144	22k	2	Welwyn	Welmet M.F.	1	1964 42200
R145	100	10	Erie	9 Carbon	¼	1723 21000
R146	560k	1	Painton	73 H.S.	¼	1707 55600
R147	560k	1			¼	1707 55600
R148	820	1	Erie	109	¼	1704 28200
RV51	5000	10	Colvern	CLR1206/9S W.W.	½	1100 26090
RV52	500	10			½	1100 26050

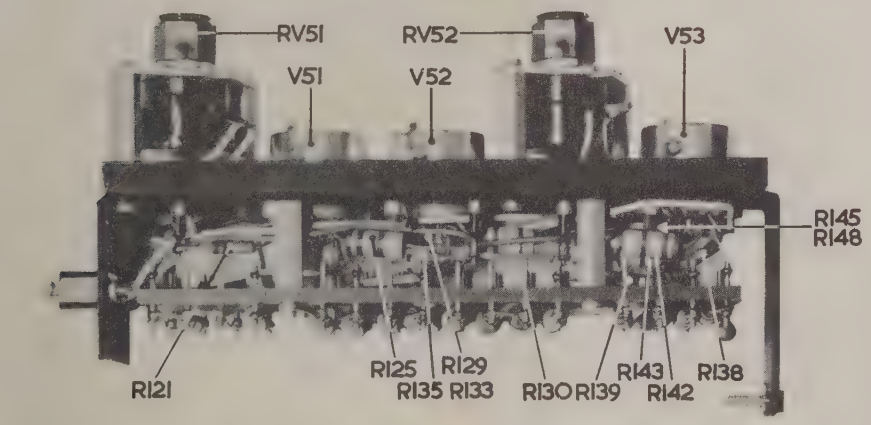
Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C51	180	10	T.C.C.	CSM20N M.S.M.	350	2085 00023
C52	15	10	Erie	P100K Ce	500	2401 11500
C53	10	10			500	2401 11000
C54	15	10			500	2401 15100

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
V51	EF86	Pentode	Mullard	
V52	12AT7	Double Triode	S.T.C.	3000 05150
V53	12AT7			3000 33020
PLJ	MP9	Plug Micronector 9-way McMurdo		3000 33020



NOTES.
1. ALL CAPACITOR VALUES ARE GIVEN IN MICRO-FARADS UNLESS OTHERWISE STATED

FIG. 8



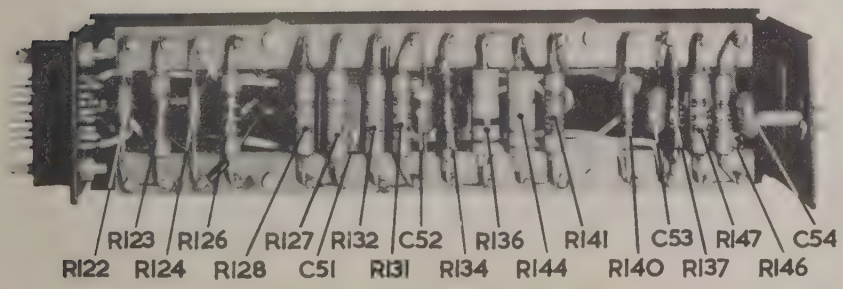


Plate 6: Sub-Unit 6

4.7. SUB-UNIT 7

Sub-unit 7 is the 0° amplifier and is almost identical to the 180° amplifier excluding the common mode rejection inverter.

Input signal from B1 on PLK is coupled through R151 into the grid of V61. R156 and RV61 are the cathode bias resistors and RV61 is adjusted for zero quiescent volts at the cathode of V62B (TP3). Output from V61 is D.C. coupled through R157, R158 into the grid of V62A, the second stage of gain. Output from V62A is coupled through R161, R162 into the grid of the cathode follower V62B. Negative feedback is taken from the cathode of V62B through the gain determining negative feedback network R164, R152, R153 to the cathode of V61. The output signal is connected to the output through the summing resistor R167. C61, C62 and C63 are provided to correct the phase shift at higher operational frequencies and eliminate parasitic oscillation.

Plug connections are as follows:—

A1	6·3 V A.C.	B1	Signal Input
A2	6·3 V A.C.	B2	—
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	—
		B5	Signal Output

Quiescent Voltages

Valve No.	Pin No.	Meter Reading	Meter Range
V61	1 & 6	98 V	250 V
	3 & 8	2 V	2·5 V
V62	1	97 V	250 V
	2	—1·7 V	2·5 V
	7	—1·8 V	2·5 V

Table 7.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.
R151	100	10	Erie	9 Carbon	¼	1723 21000
R152	12k	10			¼	1723 41200
R153	820	1	Painton	73 H.S.	½	1707 28200
R154	100k	1			½	1707 51000
R155	220k	10	Erie	9 Carbon	¼	1723 52200
R156	1000	2	Painton	73 H.S.	½	1707 31000
R157	560k	1			½	1707 55600
R158	560k	1			½	1707 55600
R159	100	10	Erie	9 Carbon	¼	1723 21000
R160	220k	1	Painton	73 H.S.	½	1707 22200
R161	560k	1			½	1707 55600
R162	560k	1			½	1707 55600
R163	100	10	Erie	9 Carbon	¼	1723 21000
R164	10k	1	Painton	73 H.S.	½	1707 41000
R165	22	10	Erie	9 Carbon	¼	1723 12200
R166	22k	2	Welwyn	Welmet M.F.	1	1964 42200
R167	1000	1	Painton	73 H.S.	½	1707 31000
RV61	5000	10	Colvern	CLR1206/9S W.W.	½	1100 26090

Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C61	100	10	T.C.C.	CSM20N M.S.M.	350	2085 00022
C62	15	10	Erie	P100K Ce	500	2401 11500
C63	22	10		P100L	500	2401 12200

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
V61	EF86	Pentode	Mullard	3000 05150
V62	12AT7	Double Triode	S.T.C.	3000 33020
PLK	MP9	Plug Micronector 9-way	McMurdo	

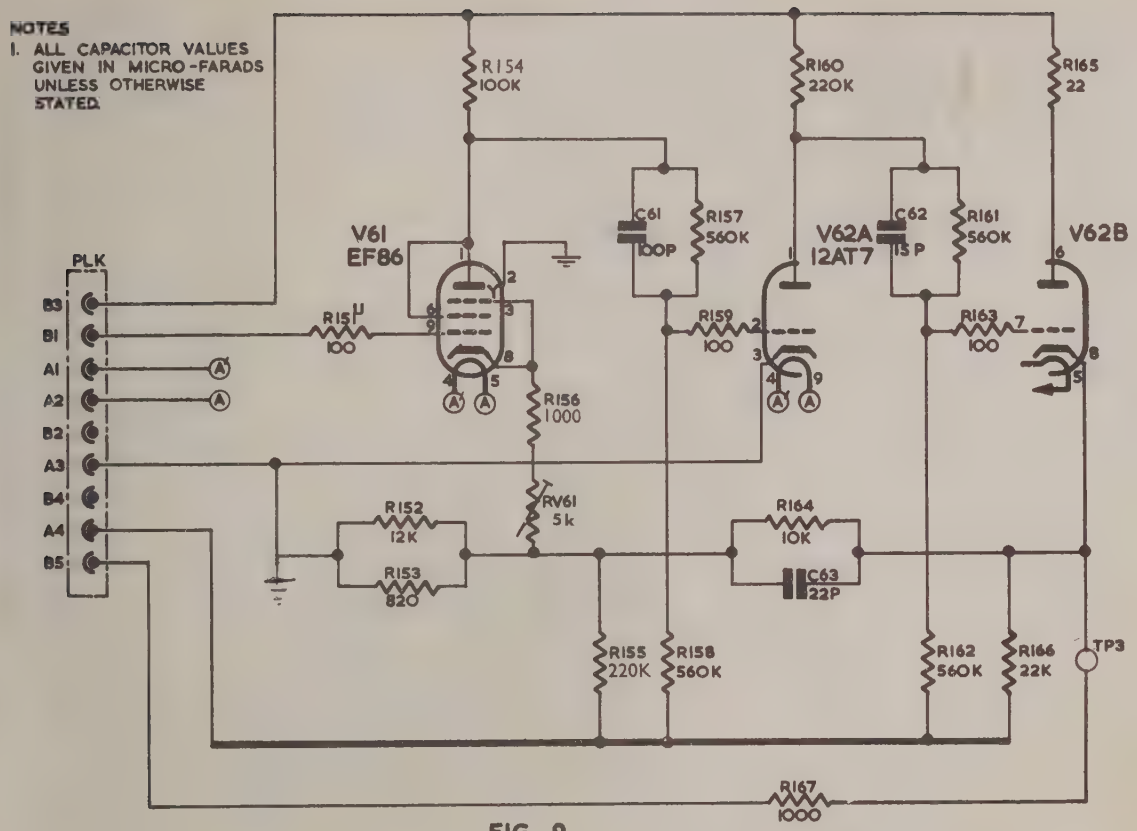


FIG. 9

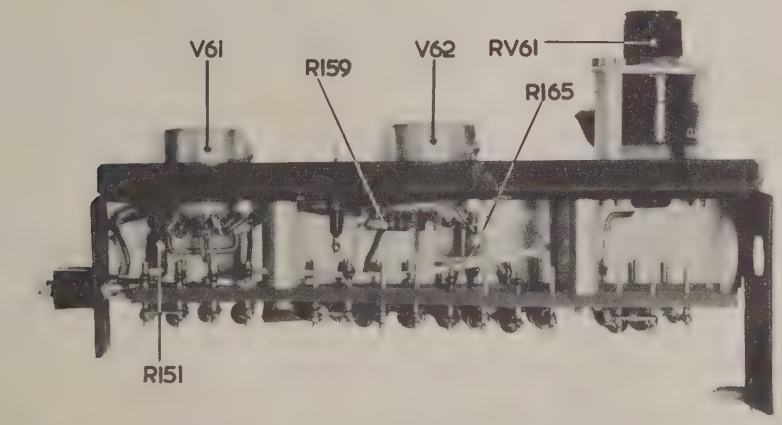


Plate 7: Sub-Unit 7

4.8. SUB-UNIT 8

Sub-unit 8 is the 0° and 180° input cathode followers and attenuators. Except for the balance–unbalance switch SC, both channels are identical, and only one will be described. It should be noted that SA and SB are ganged so that minimum sensitivity is fully clockwise on SA and fully anticlockwise on SB. Considering the 180° channel, the signal enters the equipment in the coaxial socket SKTX and is coupled through the 2 μFd capacitor C71 on to the input attenuator, controlled by SA/1R. There is no attenuation on the first six positions of this switch. The next two positions give attenuations of approximately 10 db per step in two simple ladder attenuators having impedances of 10 MΩ. The ninth position is the PRIME position which is provided so that C71 may be rapidly charged when the signal to be measured is superimposed on a large DC voltage. C72, C73 and C74 are provided to correct phase shifts at the higher operating frequencies.

The output from the high-impedance input attenuator is connected through the grid stopper R175 to the grid of the input cathode follower V71, a triode connected low noise pentode, type 6BS7. The high-impedance attenuator is returned to a negative potential at the wiper of RV71 which is adjusted to give zero quiescent potential at the cathode of V71 (TP1).

The cathode follower drives the low-impedance ladder attenuator which alters the signal transmission on the first six positions and remains constant for the remaining two. The output signal socket SKTY is connected to this attenuator through SB/1R which selects the required transmission and earths the output in the PRIME position.

The overall circuit may thus be considered as a broad band impedance transformer having various transmissions corresponding to input sensitivities for full-scale deflection of 50 mV, 150 mV, 500 mV, 1·5 V, 5 V, 15 V, 50 V and 150 V.

Plug connections are as follows:—

A1	6·3 V A.C.	B1	—
A2	6·3 V A.C.	B2	—
A3	Earth	B3	+ 200 V
A4	— 100 V	B4	—
		B5	—

180° signal input is on the coaxial socket SKTX and output on SKTY.

0° signal input is on the coaxial socket SKTZ and output on SKTAA.

Quiescent Potentials

Valve No.	Pin No.	Meter Reading	Meter Range
V71	T.C.	−9 V	10 V
V72	T.C.	−9 V	10 V

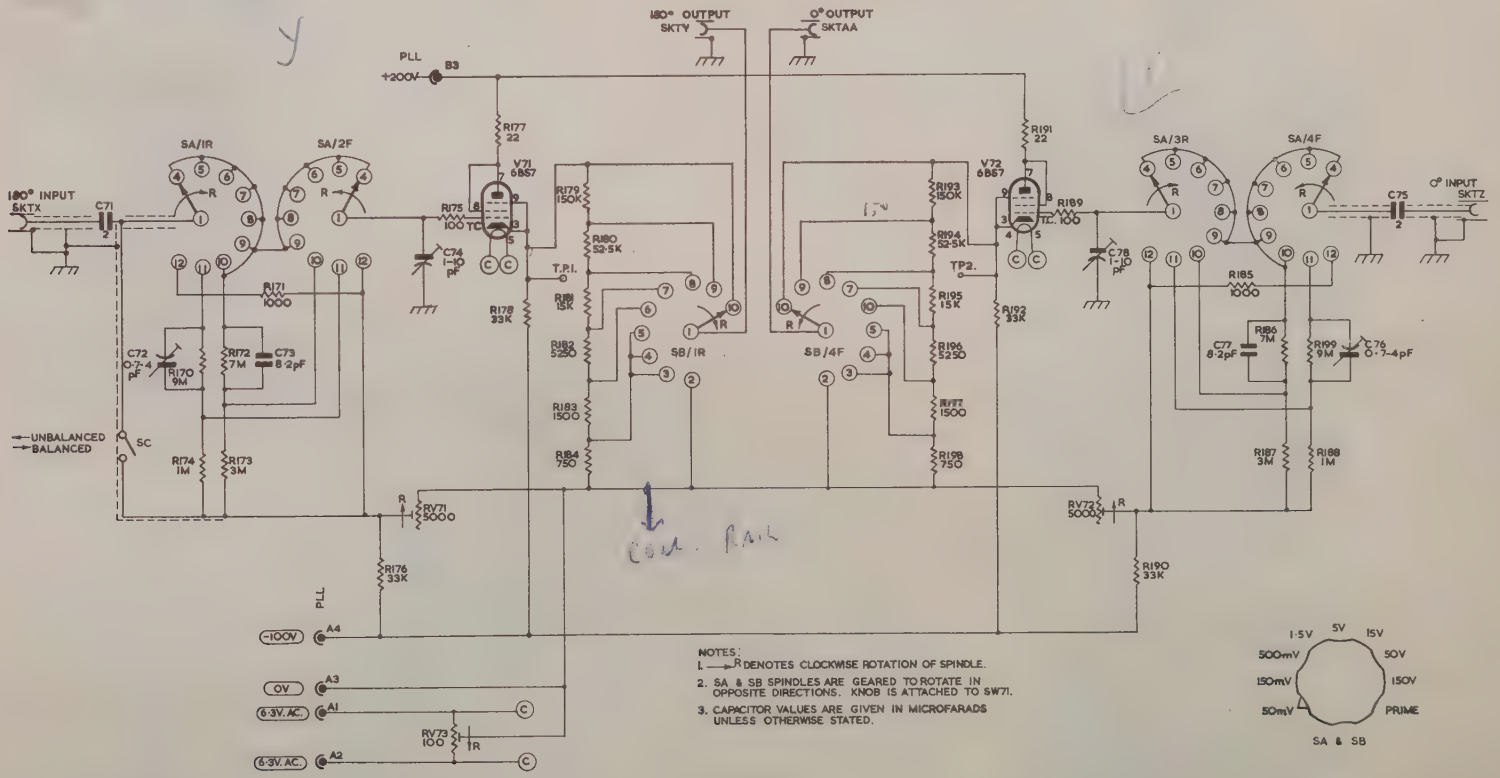
Table 8.

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.
R170	9M	1	Labgear	HS3 H.S.	¼	1707 69000
R171	1000	10	Erie	9 Carbon	¼	1723 31000
R172	7M	1	Labgear	HS3 H.S.	¼	1707 67000
R173	3M	1	Labgear	HS3 H.S.	¼	1707 63000
R174	1M	1	Painton	73 H.S.	¼	1707 61000
R175	100	10	Erie	9 Carbon	¼	1723 21000
R176	33k	10			¼	1723 43300
R177	22	10			¼	1723 12200
R178	33k	1	Painton	73 H.S.	½	1707 43300
R179	150k	1		73	½	1707 51500
R180	52·5k	1			½	1707 55250
R181	15k	1			½	1707 41500
R182	5250	1			½	1707 35250
R183	1500	1			½	1707 31500
R184	750	1			½	1707 27500
R185	1000	10	Erie	9 Carbon	¼	1723 31000
R186	7M	1	Labgear	HS3 H.S.	½	1707 67000
R187	3M	1	Labgear	HS3 H.S.	½	1707 63000
R188	1M	1	Painton	73 H.S.	½	1707 61000
R189	100	10	Erie	9 Carbon	¼	1723 21000
R190	33k	10			¼	1723 43300
R191	22	10			¼	1723 12200
R192	33k	2	Painton	73 H.S.	½	1707 43300
R193	150k	1			½	1707 51500
R194	52·5k	1			½	1707 45250
R195	15k	1			½	1707 41500
R196	5250	1			½	1707 35250
R197	1500	1			½	1707 31500
R198	750	1			½	1707 27500
R199	9M	1	Labgear	HS3 H.S.	½	1707 69000
RV71	5000	10	Colvern	CLR1206/9S W.W.	¼	1100 26090
RV72	5000	10			¼	1100 26090
RV73	100	10			¼	1100 26030

Circuit Ref.	Value Pfd.	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C71	2 μF	5	T.C.C.	CP144T Pa	600	2083 00037
C72	·7/4		Wingrove & Rogers	S50–01/1 P.T.F.E.	1K	2900 30040
C73	8·2	·25pf	Erie	P100K Ce	750	2400 08200
C74	1/10		Wingrove & Rogers	S55–11	1K	2900 30070
C75	2 μF	5	T.C.C.	CP144T Pa	600	2083 00037
C76	·7/4		Wingrove & Rogers	S50–01/1 P.T.F.E.	1K	2900 30040
C77	8·2	·25pf	Erie	P100K Ce	750	2400 08200
C78	1/10		Wingrove & Rogers	S55–11	1K	N24009

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
V71	6BS7	Low-noise Pentode	S.T.C.	3000 05230
V72	6BS7			3000 05230
SA		Switch Wafer		3724 09020
SB				3724 09010
SC		Switch Toggle	Bonella	3760 00010
SKTX	UG447/U	Socket Coaxial	Transradio	3521 01030
SKTY				3521 01030
SKTZ				3521 01030
SKTAA				3521 01030
PLL	MP9	Plug micronector 9-way	McMurdo	3521 01030



NOTES:
1. → R DENOTES CLOCKWISE ROTATION OF SPINDLE.
2. SA & SB SPINDLES ARE GEARED TO ROTATE IN OPPOSITE DIRECTIONS. KNOB IS ATTACHED TO SW71.
3. CAPACITOR VALUES ARE GIVEN IN MICROFARADS UNLESS OTHERWISE STATED.

FIG. 10.

ON SOME MODELS EF86's are used

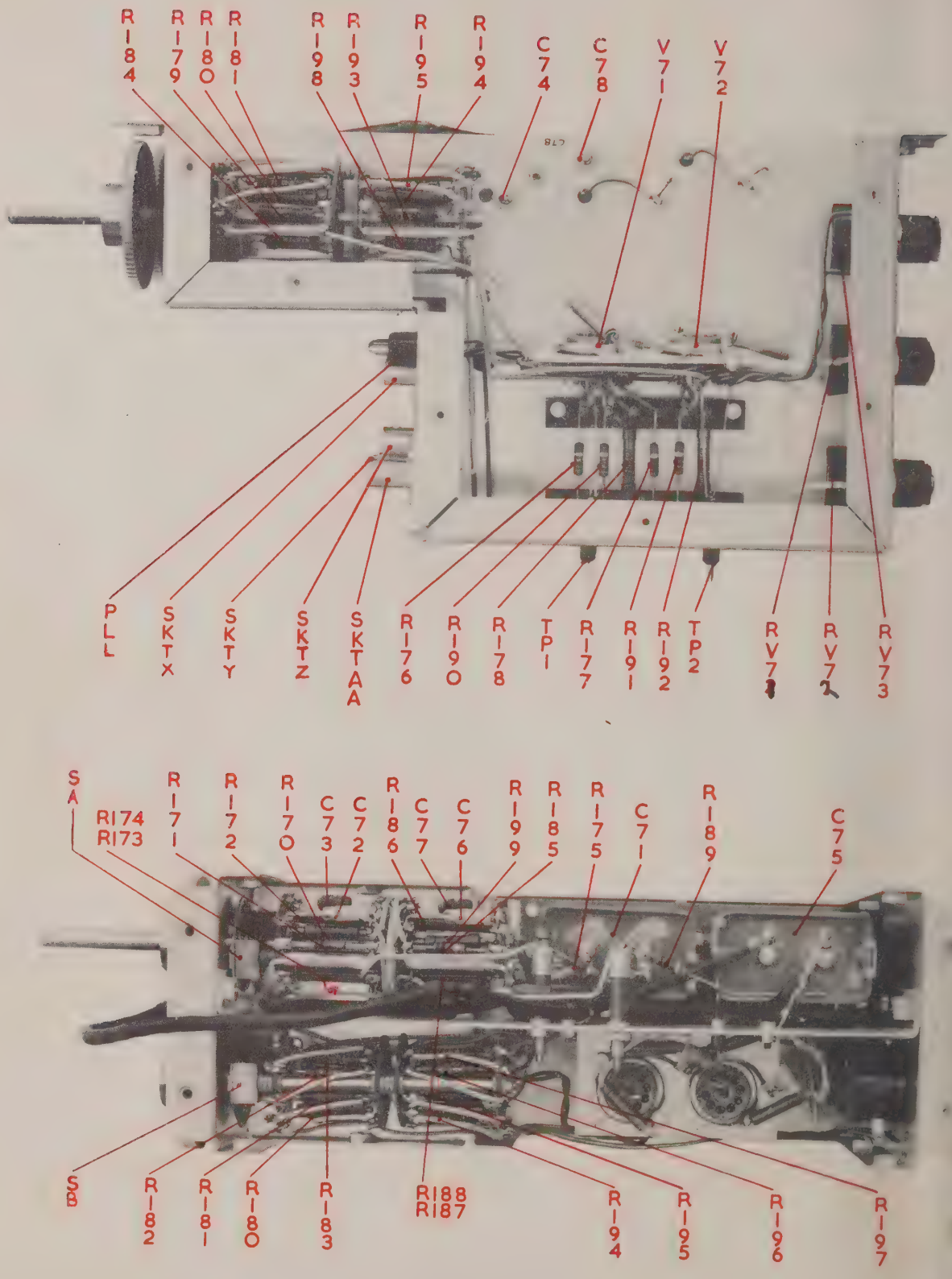


Plate 8: Sub-Unit 8

4.9. SUB-UNIT 9

Sub-unit 9 is built on a printed-circuit board and comprises four identical reference input cathode followers. The four-phase input signal is connected into the unit on four solder pins. Each phase is A.C. coupled into the grid of its respective cathode follower through a 2 μFd capacitor and in each case the grid resistor is 6·2 MΩ. The output is developed across a 220 K cathode load and A.C. coupled through a 4 μFd capacitor to the reference amplifier (sub-unit 1). The object of these cathode followers is to introduce two time constants into each reference channel so that the three time constants of the signal channel may be more easily compensated.

The solder pin connections are:—

1.	— 100V	6.	90° Input
2.	Earth	7.	180° Input
3.	+ 200 V	8.	6·3 V A.C.
4.	270° Input	9.	6·3 V A.C.
5.	0° Input		

The plug connections are:—

A1	180° Output	B1	270° Output
A2	—	B2	—
A3	—	B3	—
A4	90° Output	B4	—
		B5	0° Output

Components

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.
R201	6·2M	1	Labgear	HS3 H.S.	½	1707 66200
R202	100	10	Erie	9 Carbon	¼	1723 21000
R203	22	10			¼	1723 12200
R204	220k	10			¼	1723 52200
R205	6·2M	1	Labgear	HS3 H.S.	½	1707 66200
R206	100	10	Erie	9 Carbon	¼	1723 21000
R207	22	10			¼	1723 12200
R208	220k	10			¼	1723 52200
R209	6·2M	1	Labgear	HS3 H.S.	½	1707 66200
R210	100	10	Erie	9 Carbon	¼	1723 21000
R211	22	10			¼	1723 12200
R212	220k	10			¼	1723 52200
R213	6·2M	1	Labgear	HS3 H.S.	½	1707 66200
R214	100	10	Erie	9 Carbon	¼	1723 21000
R215	22	10			¼	1723 12200
R216	220k	10			¼	1723 52200
R217						

Circuit Ref.	Value μFd	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C81	2	5	Static	TC1785 Pa	100	2083 00031
C82	4	5		TC1786	100	2083 00032
C83	2	5		TC1785	100	2083 00031
C84	4	5		TC1786	100	2083 00032
C85	2	5		TC1785	100	2083 00031
C86	4	5		TC1786	100	2083 00032
C87	2	5		TC1785	100	2083 00031
C88	4	5		TC1786	100	2083 00032

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
V81	12AX7	Double Triode	S.T.C.	3000 33040
V82	12AX7			3000 33040

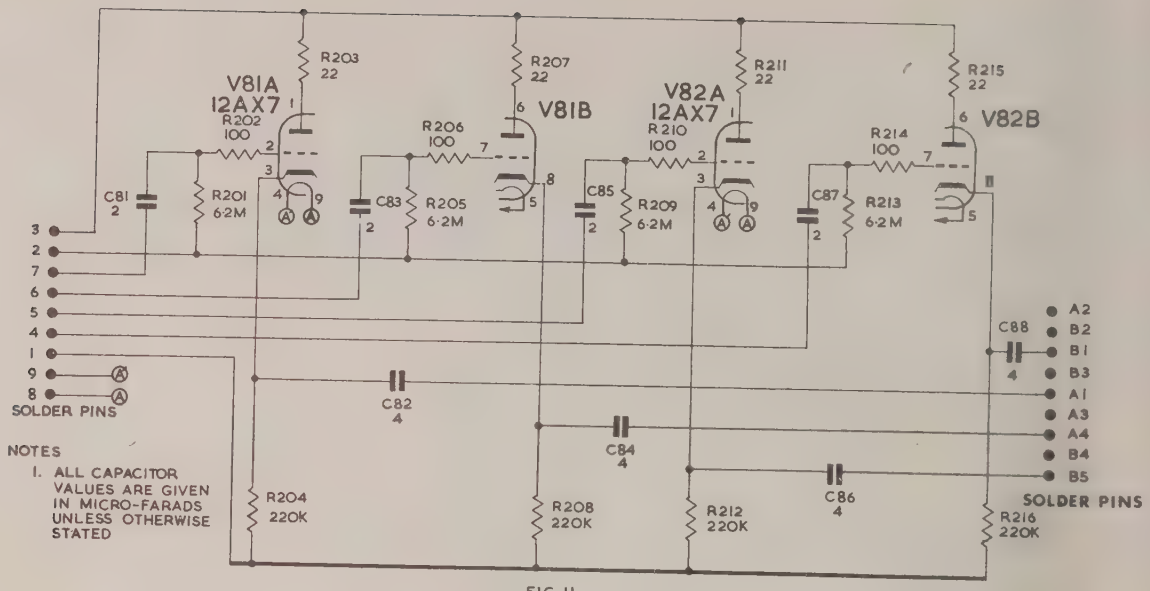


FIG. 11

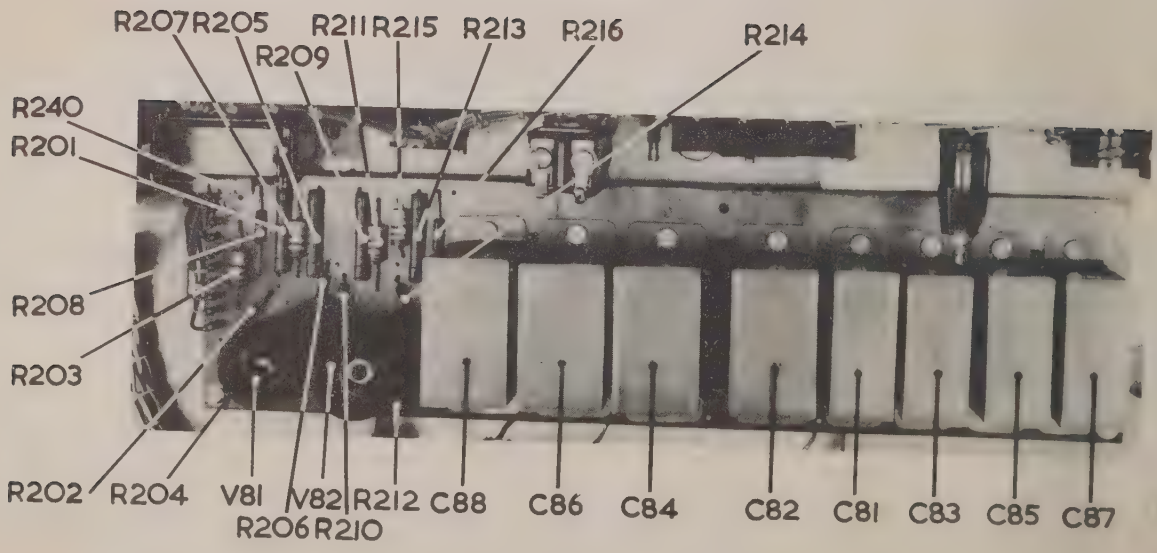


Plate 9: Sub-Unit 9

4.10 SUB-UNIT 10

This sub-unit comprises two identical d.c. chopper amplifiers, one of which operates on the reference channel and the other on the quadrature channel. The following description relates to the quadrature amplifier, but is equally applicable to the reference amplifier. The quadrature signal input is applied to the amplifier input via pin C14 of Plug PLW. The amplifier consists of two parts :—

(i) the d.c. chopper amplifier (V6a, V6b, V8a) which amplifies the low level (±7mV) output from the thermocouple bridge circuit to approximately ±3.1 volts.

(ii) the integrating impedance convertor (V7, VT1, VT2) which drives the centre-zero meter.

The input to and output from the d.c. amplifier is "in-phase" chopped by chopper relays RLB and RLC, which enables three valve stages to be used thus providing a phase-inversion at the output for negative feedback purposes. The high impedance integrating circuit following the chopper amplifier has a time constant of 2.2 seconds which integrates-out all the h.f. noise and 50 c/s ripple. L.F. noise or drift is reduced by the loop gain of the chopper amplifier which also has a 2.2 second time response due to its integrating feedback circuit R262, C105. The time constant of the integrating circuit is increased to 45 seconds when operating at frequencies below 1 c/s, by the inclusion of a 2μF polyester capacitor. Refer paragraph 4.11.

The integrating resistance R269 and bias circuit are duplicated to keep the 45 seconds capacitor operational when it is not in circuit. The emitter follower stages VT1 and VT2 respectively employ n.p.n. and p.n.p. type transistors to reduce the effect of temperature variations. Diode MR10 protects these transistors from damage when the instrument is switched-on by ensuring that VT1 input does not go more negative than—6 volts whilst the cathode-follower V17 is warming-up. Signal variation (zero shift) due to contact potential in V17 is avoided by the use of a d.c. constant current supply for the heater, which is connected in series with its counterpart V7 in the reference amplifier. This supply is obtained by diverting the 200mA h.t. load current from the negative side of the unstabilised power supply and passing it through the series connected heaters of V7 and V17. Signal output is taken from the emitter of VT7 via limiting resistors R336 and R334 to the digital voltmeter and meter respectively.

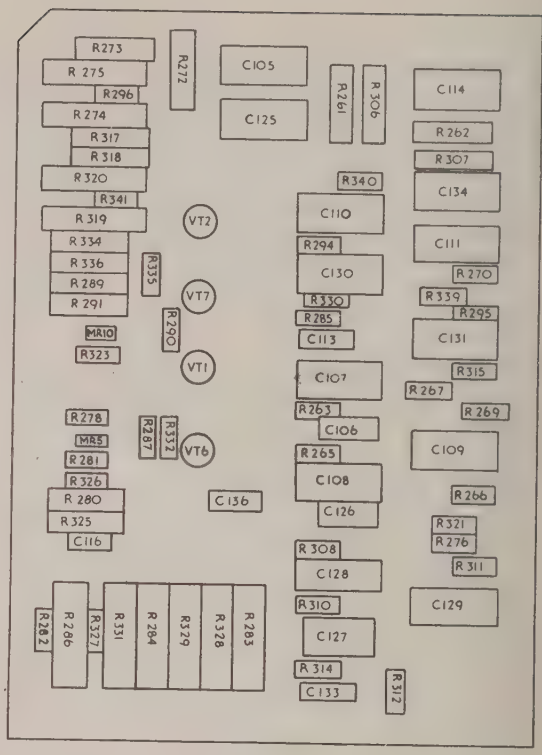
Plug PLW Pin Assignments

A1, C1 — 12V d.c. heater supply to V7 and V17.
A2, C2 — 6.3V a.c. heater supply to V6, V8, V16, and chopper relays RLB, RLC.
A3 Chopper relay supply switching.
A4 —100V supply.
A5 0V rail.
C5 Earth.
C4 300V h.t. supply.
C7 Active connection to quadrature long time-constant capacitor C135.
C8 Duplicate bias circuit to quadrature long time-constant capacitor C135.
A7 Active connection to reference long time-constant capacitor C115.
A8 Duplicate bias circuit to reference long time-constant capacitor C115.
B10, A11, C13 — Connections to reference zero set control RV7.
C12, C11, B11 — Connections to quadrature zero set control RV17.
C9 Quadrature output to digital voltmeter.
A9 Reference output to digital voltmeter.
A10 Reference output to meter.
C10 Quadrature output to meter.
C14 Quadrature input to quadrature amplifier.
A14 Reference input to reference amplifier.
A13 0V rail.

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating Watts	Solartron Part No.
R260	10k	1	Painton	92 H.S.	¼	1704 41000
R261	2.2M	1			¼	1704 62200
R262	2.2M	1			¼	1704 62200
R263	1M	10	Erie	16 Carbon	¼	1723 61000
R264	1000	10			¼	1723 31000
R265	2200	10			¼	1723 32200
R266	220k	10			¼	1723 52200
R267	1M	10			¼	1723 61000
R268	1000	10			¼	1723 31000
R269	1M	10			¼	1723 61000
R270	220K	10			¼	1723 52200
R271	2200	10			¼	1723 32200
R272	1M	1	Welwyn	C81 H.S.	¼	1704 61000
R273	1M	1			¼	1704 61000
R274	10M	1	Painton	93 H.S.	¼	1707 71000
R275	10M	1			¼	1707 71000
R276	22M	10	Erie	16 Carbon	¼	1723 72200
R278	10k	10			¼	1723 41000
R279	Not fitted					
R280	120k	1	Painton	92 H.S.	¼	1704 51200
R281	100k	10	Erie	16 Carbon	¼	1723 51000
R282	6800	10			¼	1723 36800
R283	15k	5	Painton	94 H.S.	¼	1711 41500
R284	15k	5			¼	1711 41500
R285	2200	10	Erie	16 Carbon	¼	1723 32200
R286	15k	5	Painton	94 H.S.	¼	1711 41500
R287	47k	10	Erie	16 Carbon	¼	1723 44700
R289	270	1	Welwyn	C80 H.S.	¼	1702 22700
R290	1000	10	Erie	16 Carbon	¼	1723 31000
R291	10k	1	Painton	92 H.S.	¼	1704 41000
R293	1000	10	Erie	16 Carbon	¼	1723 31000
R294	1M	10			¼	1723 61000
R295	220k	10			¼	1723 52200
R296	22M	10			¼	1723 72200
R305	10k	1	Painton	92 H.S.	¼	1704 41000
R306	2.2M	1			¼	1704 62200
R307	2.2M	1			¼	1704 62200
R308	1M	10	Erie	16 Carbon	¼	1723 61000
R309	1000	10			¼	1723 31000
R310	2200	10			¼	1723 32200
R311	220k	10			¼	1723 52200
R312	1M	10			¼	1723 61000
R313	1000	10			¼	1723 31000
R314	1M	10			¼	1723 61000
R315	220k	10			¼	1723 52200
R316	2200	10			¼	1723 32200
R317	1M	1	Welwyn	C81H.S.	¼	1704 61000
R318	1M	1			¼	1704 61000
R319	10M	1	Painton	93 H.S.	¼	1707 71000
R320	10M	1			¼	1707 71000
R321	22M	10	Erie	16 Carbon	¼	1723 72200
R323	10k	10			¼	1723 41000
R324	Not fitted					
R325	120k	1	Painton	92 H.S.	¼	1704 51200
R326	100k	1			¼	1704 51000
R327	6800	10	Erie	16 Carbon	¼	1723 36800
R328	15k	5	Painton	94 H.S.	¼	1711 41500
R329	15k	5			¼	1711 41500
R330	2200	10	Erie	16 Carbon	¼	1723 32200
R331	15k	5	Painton	94 H.S.	¼	1711 41500
R332	47k	10	Erie	16 Carbon	¼	1723 44700
R334	270	1	Painton	92 H.S.	¼	1704 22700
R335	1000	10	Erie	16 Carbon	¼	1723 31000
R336	10k	1	Painton	92 H.S.	¼	1704 41000
R338	1000	10	Erie	16 Carbon	¼	1723 31000
R339	1M	10			¼	1723 61000
R340	220k	10			¼	1723 52200
R341	22M	10	Dubilier	ETT	¼	1723 72200

Circuit Ref.	Value µFd	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C105	1	2	Wima	Tropyfol M.	125	2201 61000
C106	0.22	10	Wima	Tropyfol M.	125	2203 52200
C107	0.25	20	Hunts	AM103 M.PI.	250	2082 00003
C108	100	−20 +100	Hunts	PW104 EI.	6	2600 81000
C109	0.25	20	Hunts	AM103 M.P.I	250	2082 00003
C110	100	−20 +100	Hunts	PW104 E.I	6	2600 81000
C111	0.25	20	Hunts	AM103 M.PI.	250	2082 00003
C112	0.1	10	Wima	Tropyfol M.	125	2203 51000
C113	0.01	10	Wima	Tropyfol M.	125	2203 41000
C114	0.25	20	Hunts	AM103 M.PI.	250	2082 00003
C116	0.01	10	Wima	Tropyfol M.	125	2203 41000
C125	1	2	Wima	Tropyfol M.	125	2201 61000
C126	0.22	10	Wima	Tropyfol M.	125	2203 52200
C127	0.25	20	Hunts	AM103 M.PI.	250	2082 00003
C128	100	−20 +100	Hunts	PW104 EI.	6	2600 81000
C129	0.25	20	Hunts	AM103 M.PI.	250	2082 00003
C130	100	−20 +100	Hunts	PW104 EI.	6	2600 81000
C131	0.25	20	Hunts	AM103 M.PI.	250	2082 00003
C132	0.1	10	Wima	Tropyfol M.	125	2203 51000
C133	0.01	10	Wima	Tropyfol M.	125	2203 41000
C134	0.25	20	Hunts	AM103 M.PI.	250	2082 00003
C136	0.01	10	Wima	Tropyfol M.	125	2203 41000

Circuit Ref.	Description	Type	Manufacturer	Solartron Part No.
V6	Triode Pentode	ECF82	Mullard	3000 35010
V7	Pentode	EF86	Mullard	3000 05150
V8	Double Triode	ECC83	Mullard	3000 33040
V16	Triode Pentode	ECF82	Mullard	3000 35010
V17	Pentode	EF86	Mullard	3000 05150
VT1	Transistor	2S702	Texas	3005 50500
VT2	Transistor	ACY21	Mullard	3005 50490
VT6	Transistor	2S702	Texas	
VT7	Transistor	ACY21	Mullard	3005 50490
MR5	Zener Diode	OA91	Mullard	3005 20070
MR10	Zener Diode	OA91	Mullard	3005 20070



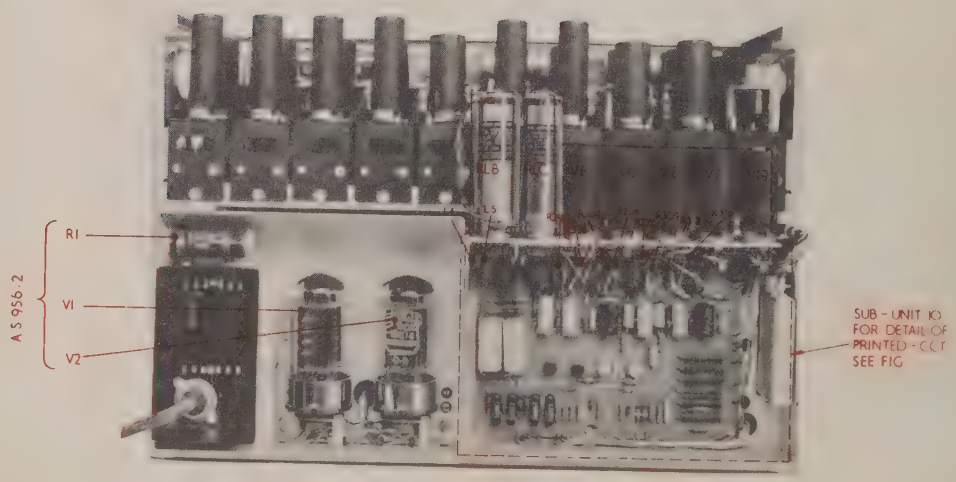


PLATE 10. COMPONENT LOCATION : REAR VIEW SHOWING SUB-UNIT 10

| | | |

284		283	291
290		286	289
282	335	328	336
329	327	331	334
2			
7		SKT W	

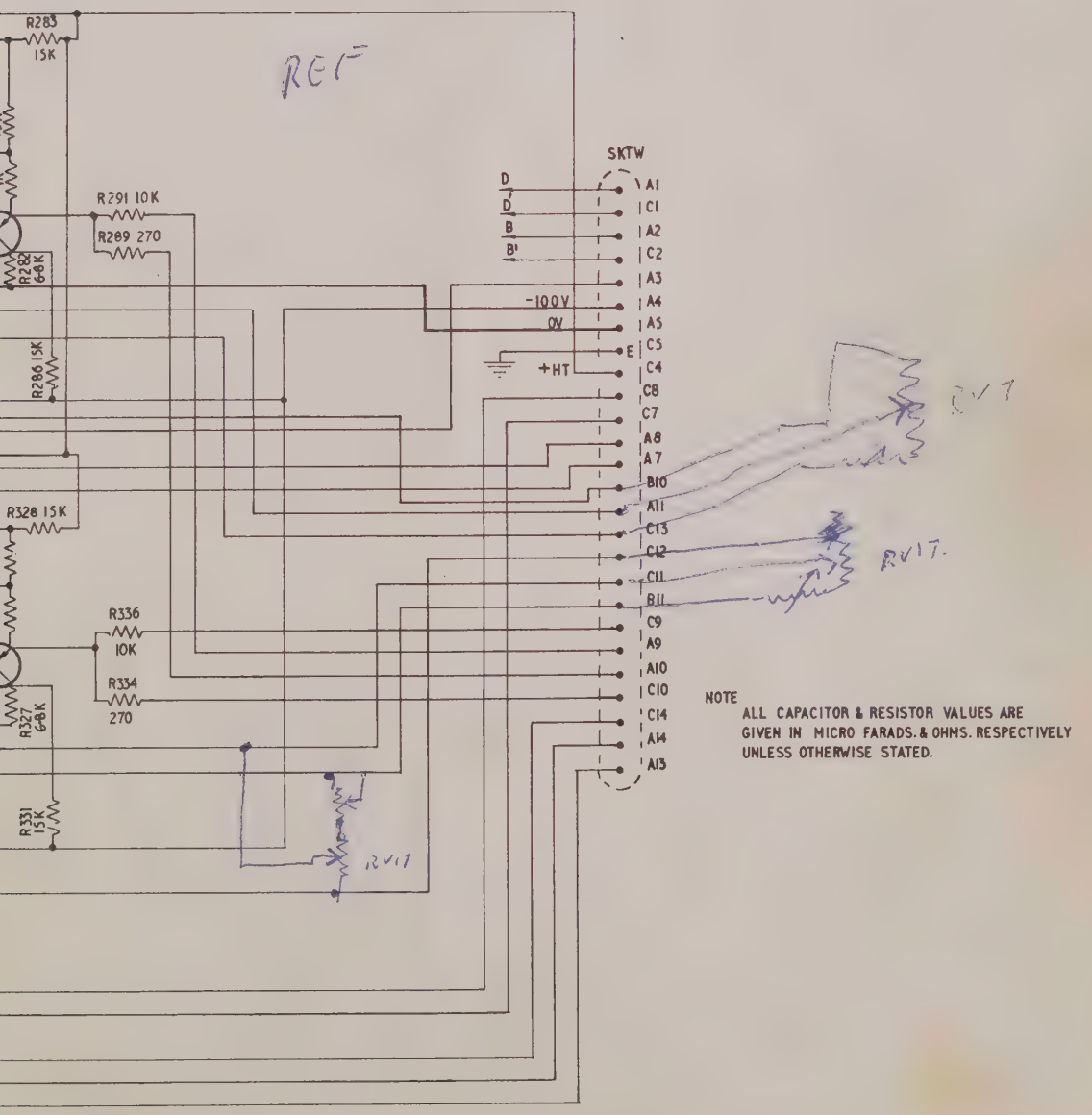


Fig. 12 Circuit Diagram: DC Amplifier

4.11. THE METER-CIRCUITS AND INTER-UNIT WIRING

The thermocouple wattmeter arrangement employed in the Resolved Component Indicator comprises two fixed resistors, two vacuo-junction thermocouples and a D.C. moving coil meter. The fixed resistors and vacuo-junction thermocouples are housed in the meter case, and the overall assembly is provided with four input terminals—see Fig. 2.

The fixed resistors and thermocouple heaters are all of equal resistance, but the value of this resistance may vary between 90Ω and 120Ω.

The fixed resistors and the thermocouple heaters are connected in Wheatstone bridge form, and the thermocouples are connected in series opposition to feed the moving coil meter.

The behaviour of this system is discussed in Appendix A.

Potentiometers RV91 and RV92 balance the reference and quadrature bridges respectively for reference drive, whilst RV96 and RV97 balance the bridges for signal drive. Reference meter zero setting is performed by the datum controls RV7 (coarse) and RV19 (fine). These controls form part of the d.c. amplifier bias circuit, and in operation are adjusted for zero volts out with no signal input. Potentiometer RV17 and variable resistor RV20 serve the same purpose for the quadrature meter.

R231, R234, and R235, R238, are in series with the signal current to the meters. These resistors are provided so that the signal voltage output from the amplifiers may be large compared with any drift signal in the output amplifier. They also swamp the resistance of the thermocouples so that constant current will flow for any thermocouple resistance in the above-mentioned range. There are similar swamp resistors in the reference current paths, but these are mounted in the reference drive amplifiers. To equalise the sensitivities of the two meters, a portion of the swamp resistor in the quadrature channel is made variable (RV93A and B) and to give this a positive and negative sweep, R242 and R241 are connected in the ' in phase ' reference channel.

When the instrument is operated in the NORMAL mode the out puts from the thermocouples are applied direct to the meter terminals via switchbanks SF/2 (reference) and SF/3 (quadrature). At the same time the 6.3 volts a.c. supply is removed from the chopper relays by switchbank SF/1. When operating over the range 1 c/s—1 kc/s, the thermocouple outputs are disconnected from the meter inputs, and applied instead to the reference and quadrature d.c. amplifiers. The resultant outputs from these amplifiers are applied to the meters via a series resistance (R333, RV16, RV15 in the case of the quadrature circuit). Due to the phase inversion occurring in the d.c. amplifiers the meter drive voltage is now applied at terminal 6 and not at terminal 4 as on NORMAL operation. Resistors R333 and RV16 can be shorted-out to provide x10 meter magnification by closing switch SM. The long time-constant integrator capacitors C115 and C135, are charged ready for use via switchbank SF/4 and the duplicate networks contained in the d.c. amplifiers. Operation on the lowest frequency range (0.05-1 c/s) is similar to that described for the 1 c/s-1 kc/s range, except that the long time-constant integrating capacitors C115 and C135 are now switched into circuit by switchbank SF/4. The ±2.8 volts output from the d.c. amplifier is divided down to ±1.5 volts by R337, RV18 and R291 (d.c. amplifier circuit) for application to the digital voltmeter at SKTBB, or SKTCC in the case of the quadrature signal. Thus the voltmeter gives the correct reading for the 1.5 V input range of the VP253.3, and, ignoring the decimal point, the correct digital reading for all ranges that are decades of 1.5 V. On other ranges, the reading is obtained by ignoring the decimal point and dividing by three.

Potentiometers RV 91 and RV 92 balance the reference and quadrature bridges respectively for reference drive, whilst RV96 and RV97 balance the bridges for signal drive. Reference meter zero setting is performed by the datum controls RV7 (coarse) and RV19 (fine). These controls form part of the d.c. amplifier bias circuit, and in operation are adjusted for zero volts out with no signal input. Potentiometer RV17 and variable resistor RV20 serve the same purpose for the quadrature meter.

The main interconnecting wiring between sub-units is by means of a printed-circuit board running along the centre of the instrument. This carries all the sockets into which the sub-units plug, and a number of components are also mounted on it.

Circuit Ref.	Value Ohms	Tol. %	Manufacturer	Type	Rating	Solartron Part No.
R231	1200	1	Painton	93 H.S.	¼	1707 31200
R232	1200	1			¼	1707 31200
R233	1200	1			¼	1707 31200
R234	1200	1			¼	1707 31200
R235	1200	1			¼	1707 31200
R236	1200	1			¼	1707 31200
R237	1200	1	Painton	93 H.S.	¼	1707 31200
R238	1200	1			¼	1707 31200
R239	1000	10	Erie	16 Carbon	¼	1723 31000
R240	47	5	Welwyn	F32 M.F.	2	1930 14700
R241	100	10	Erie	16 Carbon	¼	1723 21000
R242	100	10			¼	1723 21000
R243	10k	10			¼	1723 41000
R244	10k	10			¼	1723 41000
R245	1200	1	Painton	93 H.S.	¼	1707 31200
R246	1200	1	Painton	92 H.S.	¼	1707 31200
R247	1200	1			¼	1707 31200
R248	1200	1			¼	1707 31200
R277	10k	10	Erie	16 Carbon	¼	1723 41000
R288	2400	1	Painton	92 H.S.	¼	1704 32400
R292	10k	1			¼	1704 41000
R322	330	5	Painton	306A W.W.	6	1737 23300
R333	2400	1	Painton	92 H.S.	¼	1704 32400
R337	10k	1			¼	1704 41000
RV5	250	10	Colvern	CLR1206, 9S W.W.	¼	1100 26040
RV6	2500	10			¼	1100 26080
RV7	25k	10			¼	1100 26110
RV8	10k	10			¼	1100 26100
RV15	250	10			¼	1100 26040
RV16	2500	10			¼	1100 26080
RV17	25k	10			¼	1100 26110
RV18	10k	10			¼	1100 26100
RV19	2.5k	10			¼	1100 26080
RV20	2.5k	10			¼	1100 26080
RV91	5000	10			¼	1100 26090
RV92	5000	10			¼	1100 26090
RV93	250/250	10	AB Metals	43 W.W.	1	1106 02020
RV94	100	10	Colvern	CLR1206 9S W.W.	¼	1100 26030
RV95	100	10			¼	1100 26030
RV96	5000	10			¼	1100 26090
RV97	5000	10			¼	1100 26090

Circuit Ref.	Value µFd	Tol. %	Manufacturer	Type	Rating Volts	Solartron Part No.
C91	8	20	Hunts	WP214 M.P.a	150	2083 50004
C92	8	20			150	2083 50004
C93	0.5	25	Hunts	B908 M.P.a	250	2351 55000
C94	1	25	Hunts	B509 M.P.a	250	2351 61000
C95	1	25	Hunts	B509 M.P.a	250	2351 61000
C115	2	2	Hunts	A41 103 M.P.o	150	2082 00022
C135	2	2			150	2082 00022

Circuit Ref.	Type	Description	Manufacturer	Solartron Part No.
RLB	CK3	Synchronous Chopper 6.3V 50 c s	A.E.I.	3006 10010
RLC	CK3	Synchronous Chopper 6.3V 50 c s	A.E.I.	3006 10010
L4		Choke R.F. Fixed 22µH.		3050 20090
L5		Choke R.F. Fixed 22µH.		3050 20090
L1		Choke, Resistive 0.8µH 1Ω		3050 40010
SD	8821/K5	Switch, Toggle	N.S.F.	3760 00100
SE		Switch, Toggle	Bonnella	3760 00030
SF		Switch, Wafer		3724 09030
SG	72	Switch, Slider SP DT	N.S.F.	3750 00040
SH	80, 10, 1466, HF	Switch, Push Button	Thorn	3775 00010
SM	72	Switch, Slider SP DT	N.S.F.	3750 00040
PSU	AS956.2	Power Sub Unit	Solartron	
TL1	L1499 ISB	Terminal Black	Belling & Lee	3551 00160
TL2	L1499 ISB		Belling & Lee	3551 00160
TL3	L1499 ISB		Belling & Lee	3551 00160
TL4	L1499 ISB		Belling & Lee	3551 00160
TL5	L1499, ISB		Belling & Lee	3551 00160
LP1		Lamp Capless 6.3V 0.3A	Siemens Ediswan	3007 10120
LP2	X959119	Lamp Midget 6V 0.1A	Thorn	3007 10110
M1		Meter (Reference)		3400 20030
M2		Meter (Quadrature)		3400 20050
PLAA	BN7, 7	Plug (Elbow) co-axial	Transradio	3510 01100
PLY	BN7, 7	Plug (Elbow) co-axial	Transradio	3510 01100
PLZ	UG260 U	Plug co-axial	Transradio	3510 01030
PLX	UG260, U	Plug co-axial	Transradio	3510 01030
SKTA	MS109	Socket Micro-nector 9-way	McMurdo	3525 09010
SKTB	MS109		McMurdo	3525 09010
SKTC	MS109		McMurdo	3525 09010
SKTD	MS109		McMurdo	3525 09010
SKTE	MS109		McMurdo	3525 09010
SKTF	MS109		McMurdo	3525 09010
SKTG	MS109		McMurdo	3525 09010
SKTH	MS109		McMurdo	3525 09010
SKTJ	MS109		McMurdo	3525 09010
SKTK	MS109		McMurdo	3525 09010
SKTL	MS109		McMurdo	3525 09010
SKTQ	Not fitted			
SKTR	MS126	Socket Micro-nector 26-way	McMurdo	3525 26010
SKTS	CZ49221	Socket 4-way Mk 4	Plessey	3524 04010
SKTT	UG447 U	Socket co-axial	Transradio	3521 01030
SKTU	UG447 U	Socket co-axial	Transradio	3521 01030
SKTV	UG447, U	Socket co-axial	Transradio	3521 01030
SKTW	MS14P	Socket 4-way	McMurdo	

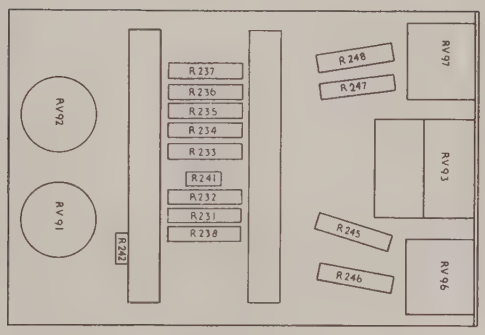


FIG 15. METER BOARD

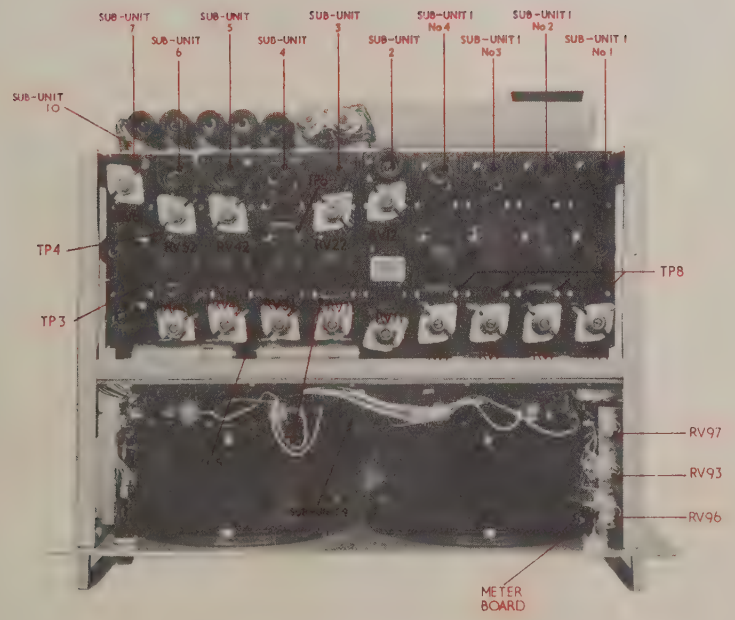


PLATE II. COMPONENT LOCATION. TOP VIEW

MAINTENANCE INFORMATION

To remove the instrument from its case, remove the four panel-fixing screws at the sides of the panel, and the single screw through the bottom of the case at the rear. Open the door in the right-hand side of the case and check that the mains lead is not trapped. Withdraw the instrument from the case.

To remove any of the sub-units one to seven, unscrew the captive fixing screw which holds the sub-unit chassis to the main assembly, and withdraw the sub-unit from the rear of the frame. When replacing these sub-units, ensure that the plug on the sub-unit mates correctly with the socket on the main assembly.

To remove the power supply sub-unit remove the heat shield which is held in place by three countersunk screws through the back member of the frame, unplug the power supply from the socket attached to the front panel. Remove the four fixing bolts which hold the power unit to the bottom of the frame. The unit may then be removed through the rear of the frame.

To remove sub-unit 8, remove the sensitivity control knob and unscrew the balance, unbalance switch from the front panel. Unscrew four screws holding sub-unit 8 to the bottom of the frame. Disconnect four coaxial sockets and one micronector. Sub-unit 8 may then be withdrawn from the main frame. The side plates may then be removed to obtain access to the components. When all other sub-units have been removed, the meters may be withdrawn, and sub-unit 9 is then accessible. This may be unscrewed from the main frame, and removed after unsoldering connections to nine solder pins and unplugging the nine-way micronector.

As a guide during servicing, an abridged copy of the setting up and test procedure is given followed by a table of possible faults and a fault-finding procedure.

Setting-up Procedure

The following equipment will be required in order to carry out the tests called for in this specification :—

Voltage Dividing Unit 0.5% accuracy, *e.g.*, Sullivan Decade Potentiometer or Kelvin Varley Divider.

Screened Resistors :—1MΩ ± 10% Grade 1, 1/8W (especially made up to isolate from chassis).

Sub-standard r.m.s. Voltmeter, or r.m.s. calibrator; accuracy ±0.5%; output 150 V max., *e.g.*, Solartron LM902.2 and LM903.

An r.m.s. voltmeter possessing an input resistance not less than 50 MΩ on all ranges, *e.g.*, Solartron VP 252·2.

DC voltmeter possessing an input resistance of not less than 20 kΩ/V and an accuracy of 2% of f.s.d., *e.g.*, AVO meter Model 8.

Cathode Ray Oscilloscope, *e.g.*, Solartron CD1014·3.

AF Generator of frequency range 50 c/s to 1 kc/s, accuracy 2%, and an output variable up to 10 V r.m.s. ; the output voltage accurate to 5%, *e.g.*, Solartron CO 546·2.

AF 4-Phase Generator, 0°, 180°, 90° and 270°, with a separate signal output. The output voltage to be variable up to not less than 10 V r.m.s. Frequency range to be 0.5 c/s to 1 kc/s accurate to within ±1.5%, *e.g.*, Solartron Oscillator OS103.3.

Thermocouple Milliammeter, range 0-20mA r.m.s. Accuracy 2% of f.s.d.

Two dummy Wattmeters (Fig.16).

Amplifier to provide 40 volts and 100 volts r.m.s. from a 10 volt source (Fig.17).

Digital Voltmeter, *e.g.*, Solartron LM902.2.

DC Voltmeter, accuracy ±0.5% f.s.d. to measure 100 volts and 300 volts d.c., *e.g.*, E.I.L. Model 44.

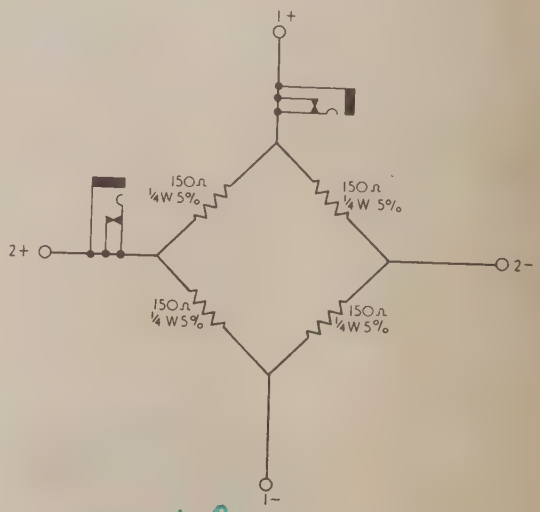


FIG 16 ?

During factory test, in order to protect the thermocouple meters against overload, dummy networks as shown in Fig. 15 replace the actual meters. Check that the mains selector panel is correctly set and that the sub-units have been replaced in their correct positions. Connect 0·1μFd capacitors of 150 V working in series with C91 and C92.

Set the instrument controls as follows: to 'Prime', 'Balanced Input' and 'Direct Earth'.

Switch on the instrument and allow 15 minutes to warm up.

Check the H.T. supply to be 300 V ± 1% using a sub-standard meter. If necessary, adjust RV1 on the power supply sub-unit to obtain the required reading. Check that the — 100 V rail is accurate to ± 1% and if necessary adjust RV12 on sub-unit 2.

Connect an Avometer model 8 between the earth terminal and the following test points, adjusting the relevant potentiometers for zero D.C. on the 2·5 V meter range.

Sub-unit	*Test Point*	*Potentiometer*
S.U. 8	T.P. 1	RV71
	T.P. 2	RV72
S.U. 7	T.P. 3	RV61
S.U. 6	T.P. 4	RV51
S.U. 5	T.P. 5	RV41
S.U. 4	T.P. 6	RV31
S.U. 3	T.P. 7 or CRO. SKT.	RV22
S.U. 1 (4 off)	T.P. 8	RV1

Test points 1 and 2 are on the top of sub-unit 8 and are accessible from the left-hand side of the instrument.

Initial Amplifier Settings

Set the VP253 sensitivity to 5 V and monitor the output at the C.R.O. socket with an A.C. millivoltmeter (VF252). Connect a 5 V r.m.s. 80 c/s signal from a wide range oscillator (CO546) to the 0° and 180° signal inputs simultaneously. Adjust RV52 for minimum indication on the A.C. millivoltmeter. This voltage is normally less than 20 millivolts.

Disconnect the 180° input and switch to unbalance. Adjust RV42 for an indication of 6·5 V on the A.C. millivoltmeter. Disconnect the oscillator.

Hum Balance Adjustments

Connect screened 1 MΩ resistors from the 0° and 180° input sockets to earth. Switch to ' Balanced ' and set the sensitivity control at 150 mV.

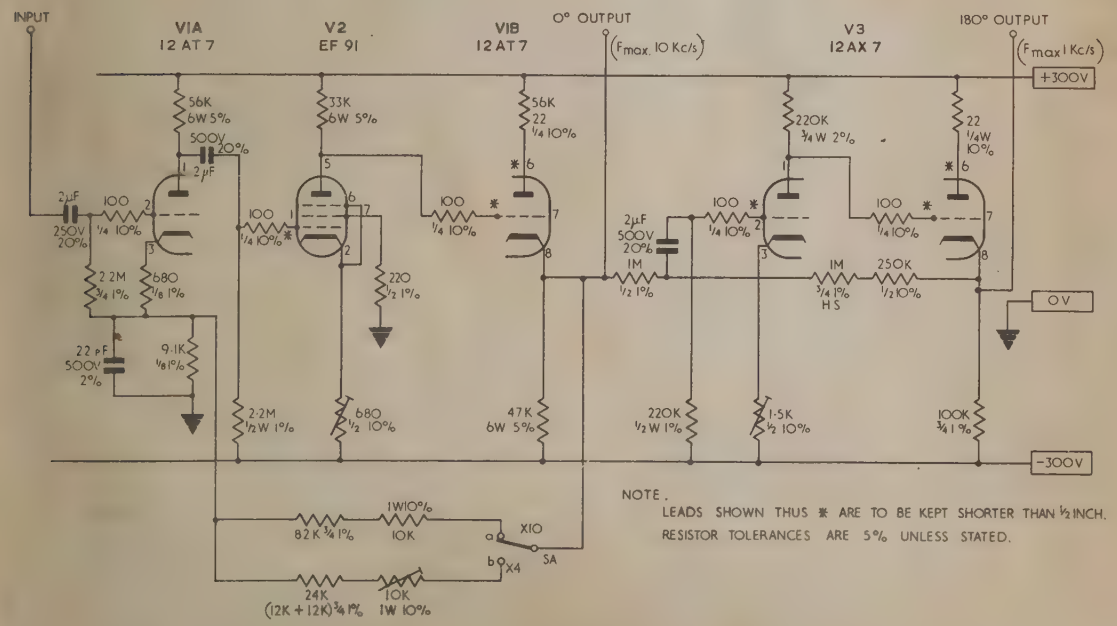
Adjust RV94 and RV95 for minimum output at the CRO socket as measured with the A.C. millivoltmeter.

Set the sensitivity to 50 mV and adjust RV73 for minimum output. Measure the hum under the input conditions shown and see that the figures do not exceed those recorded in the following table.

Range	**Hum Outputs**		**Input Sockets**
	Balanced	*Unbalanced*	
50 mV	30 mV	30 mV	Screened.
150 mV	12 mV	12 mV	1 MΩ resistors
500 mV	12 mV	12 mV	to earth.
50 mV	25 mV	25 mV	Short circuit to
150 mV	10 mV	10 mV	earth.
500 mV	12 mV	12 mV	

Signal Distortion and Overdrive

Set the instrument to ' unbalanced ' with the sensitivity control at 5 V. Connect a 5 V 80 c/s signal from an oscillator to the 0° input. Connect an oscilloscope (CD513) to the output of sub-unit 4. Connect the thermocouple milliameter in series with the 2 + lead of the dummy ' reference ' meter. Increase the input signal until distortion is just apparent on the peaks of the output waveform. The current in the thermocouple milliameter should not exceed 8 mA. Switch to the 50 mV sensitivity range and note that the current does not exceed 12 mA. Repeat this test with the thermocouple meter in series with the 2 + lead of the quadrature meter.



IGNORE L4 ADJUSTMENT

Reference Distortion and Overdrive

This test is similar to that which has just been described for the signal channel, but in order to get adequate signal to overdrive the reference channel, the test amplifier (Fig. 16) is used.

Set the test amplifier to × 10 balanced output and connect the two outputs to the 0° and 180° reference input terminals. Supply the test amplifier with a zero amplitude 80 c/s signal from the oscillator. Connect an oscilloscope to the output of sub-unit 1/2, and connect the thermocouple milliameter in series with the 1 + lead of the dummy reference meter. Switch the VP253 to ' Prime '. Increase the oscillator output amplitude until distortion is just visible on the output of sub-unit 1/2. Check that similar distortion appears on the output of sub-unit 1/3. The current in the thermocouple milliameter should be greater than 11 mA. Increase the oscillator output to maximum and check that the current reading is less than 17 mA. Connect the outputs of the amplifier to the 90° and 270° reference input terminals and repeat the above test measuring the current in the 1 + lead of the quadrature meter and monitoring the outputs of sub-units 1/1 and 1/4.

Overload Indicator

Set the VP253 to 5 V unbalanced input and supply a 5 V r.m.s. 80 c/s signal to the 0° input. Increase the signal amplitude to $\sqrt{2} \times 5$ V r.m.s. and adjust RV11 until the overload indicator flashes regularly. Make a final adjustment so that with 7·0 V input there is no overload indication and at 7·2 V input there is.

Reset the oscillator to 5 volts output and connect an oscilloscope to the C. R. O. socket. Increase the VP253.3 sensitivity to 50 mV and after a pause of 10 seconds return to the 5V range. The overload indicator will continue to flash at approximately 1 c/s and the oscilloscope will indicate severe distortion. Press the reset button for a few seconds and on release, the overload symptoms should have disappeared.

This completes the initial setting up.

The 0·1 μFd capacitors are now removed and C91 and C92 are reconnected in the normal way. The dummy meters are replaced by a pair of thermocouple wattmeters and the mechanical zeros of the meters are accurately set. The instrument is then switched on, allowed 15 minutes to warm up. and the D.C. levels are checked. A 10 V. 80 c/s. four-phase reference supply is connected to the instrument by the four-core cable supplied.

Set the VP253 to 15 V balanced and connect the 0° input to each of the four reference phases in turn. Check that the deflection sense agrees with the accompanying table.

0° *Socket to*		*Meter Indication*
0°	REF. TERMINAL	REF. in phase
90°	,, ,,	QUAD lead.
180°	,, ,,	REF. reverse phase.
270°	,, ,,	QUAD lag.

Integrating DC Amplifier Check

Disconnect the 10 V 80 c/s 4-phase drive and set the mode selector to the "1 c/s-1 kc/s" position. Connect a d.c. coupled oscilloscope to pin 2 of the chopper relay RLC, and check that the 50 c/s waveform is not greater than 10 V in amplitude. Connect the oscilloscope to pin 3 of RLC and adjust the hum compensating inductor L4 for minimum 50 c/s amplitude, checking that it is less than 10V in amplitude after adjustment. Set panel DATUM controls to mid-position. Switch to x10 meter expansion for both quadrature and reference meters and adjust RV17 and RV7 for zero readings within ±2% of meters f.s.d. (½ division on top scale).

Meter Datum and Sensitivity Adjustments

Set the OS103.3 to 500 c/s, and by monitoring with the sub-standard r.m.s. voltmeter, set the output level of each phase to 10V ±0.5%, within ±0.2% of each other. Switch the VP253.3 to the 5V range, and leave the meter scale expansion switches in the x10 positions. Apply a 5V, 550 c/s signal to the VP253.3 input, and adjust the signal bridge balancing potentiometers RV96 and RV97 for zero deflections on the reference and quadrature meters respectively. Remove the input signal and reconnect the four-phase 10V, 500 c/s reference drive. Adjust reference balancing potentiometers RV91 and RV92 for zero deflections within ±2% of meter f.s.d. Re-check reference balance. Remove the four-phase drive and connect two leads from the OS103.3 reference 0° and 180° outputs to the VP253.3 0°, 90° and 180°, 270° inputs respectively such that the quadrature meter operates as a reference meter. Ensure that there is an earth lead between the two instruments. Set the VP253.3 to 15V range, and set SWF to NORMAL. Connect VP253.3 0° input socket to the 10V, 80 c/s 0° source, and note indications on reference and quadrature meters. Connect the 0° input socket to the 10V, 80 c/s, 180° source, and again note reference and quadrature meter indications. Adjust RV42 and RV93 to obtain reference and quadrature meter readings as close to 10V as possible (*i.e.*, spread symmetry errors equally about 10V). Permissable tolerance ±1%. Short circuit signal inputs to earth. Set meter expansion switches to x10, set SWF to "1 c/s —1 kc/s" position, and check datums. Connect the VP253.3 0° input, via an accurate 10 : 1 attenuator to the 10V 0° and 180° sources in turn, and adjust RV5 for 2/3 f.s.d. ±2% (in-phase and reverse-phase respectively) on reference meter, and RV15 for 2/3 f.s.d. ±2% (lead to lagging respectively) on quadrature meter. Set the reference and quadrature meter expansion switches to x1 and remove attenuator. Connect VP253.3 input to the 10V, 0° and 180° sources in turn and adjust RV6 for 2/3 f.s.d. ±1% (10V in-phase to 10V reverse-phase respectively) on the reference meter, and RV16 for 2/3 f.s.d. ±1% (10V lead to 10V lagging respectively) on the quadrature meter. Set the digital voltmeter to its 1.5V range, and connect to quadrature DVM socket, and re-check datums. Connect the VP253.3 0° input to the 10V, 0° and 180° sources in turn, and adjust RV18 for +1.000V and -1.000V ±1½% respectively. Repeat with the digital voltmeter

connected to the reference DVM socket, adjusting RV8 for +1.000V and -1.000V ±1½% respectively.

Performance Tests

The arrangement of test equipment required for performance tests on the VP253 is shown in Fig. 18

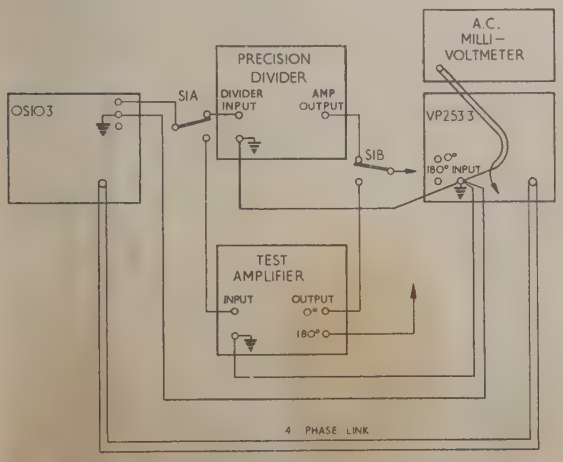


FIG.18

The input signals are monitored by the A.C. millivoltmeter, which should be checked against a sub standard meter. All test gear should be allowed 30 minutes to warm up. Set VP253.3 to NORMAL.

Switch to balanced and supply an 80 c/s input signal from the 0° reference terminal to the 0° input with the 180° input earthed, and repeat the test supplying signal to the 180° input with the 0° input earthed.

Adjust the input signal amplitude in accordance with the table below, and check that the meter accuracy is better than ±2% of full scale deflection on all ranges, except the 15V range, where the error should not be more than ±1%.

The quadrature meter reading should be zero ± 1% of full scale deflection.

Range	50 mV	150 mV	500 mV	1·5 V
Input	40 mV	100 mV	400 mV	1·0 V
Range	5 V	15 V	50 V	150 V
Input	4 V	10 V	40 V	100 V

Frequency Coverage

Apply 10V at 0.5 c/s to the 0° input socket and adjust RV21 until the quadrature meter swings uniformly about zero. Check that the quadrature meter swing is less than ±1V and that the reference meter swings between 8-12V in phase.

Set the VP253.3 to the 15V range, and connect the 0° input to the 10V, 0° source and the 180° input to the 10V, 270° source, with the oscillator set to 80 c/s. Note the reference and quadrature readings obtained with the mode selector set to the NORMAL position, and check that the readings do not change by more than 1% when the selector is set to the "1c/s-1kc/s" position.

Set the mode selector to the "0.05-1c/s" position, and wait for 5 minutes. Return selector to the "1c/s-1kc/s" position, and check that the reference and quadrature meter readings do not change by more than 0.5%. Return selector to the "0.05-1 c/s" position, disconnect the input, and check that the reference and quadrature meter readings are reduced to 1/3rd within the time-limit 35-60 seconds. Set oscillator frequency to 0.1c/s and connect the 0° input to the 10V, 0° source and the 180° input to the 10V, 270° source. Set mode selector to the "0.05-1c/s" position and check that the reference and quadrature meter readings after 5 minutes are approximately 3% lower than that previously noted with an oscillator input of 80 c/s. Check that the beat on the reference and quadrature meters are approximately ±4% of the reading.

Set oscillator frequency to 0.05 c/s and after 5 minutes check that the reference and quadrature meter readings are approximately 12% lower than that noted with an oscillator input of 0.1 c/s. Check also that the beat on the meters is approximately ±8% of reading.

Set VP253.3 to 50V range and apply a 1 kc/s signal at 40V to the 0° input socket. (The amplifier supplying 40V is fed from the 0° output of the OS103.3). Adjust C78 for zero within ±2% of quadrature meter f.s.d. Transfer the signal source from the 0° output to the 180° output of the OS103.3. Note quadrature meter reading, and if necessary, re-adjust C78 for optimum, *i.e.*, one half of any amount that the quadrature meter may read with respect to zero, thus equalising any small error that may exist. Turn VP253.3 range selector to 150V, and increase input signal to 100V from 0° output of OS103.3. Adjust C76 for zero within ±2% of quadrature meter f.s.d. Transfer signal source from the 0° output to the 180° output of the OS103.3. Note quadrature meter reading, and if necessary re-adjust C76 for optimum, *i.e.*, one half of any amount that the quadrature meter may read with respect to zero.

Set VP253.3 to 50V range, earth the 0° input socket and apply a 1 kc/s signal at 40V to the 180° input socket from the 0° output socket of the OS103.3. Adjust C74 for zero within ±2% of quadrature meter f.s.d. Transfer signal source from 0° to the 180° output of OS103.3. Note reading on quadrature meter, and if necessary, re-adjust C74 for optimum, *i.e.*, one half of any amount that the meter may read with respect to zero. Set VP253.3 to 150V range, increase input signal to 100V from 0° output socket of OS103.3. Adjust C72 for zero within ±2% of quadrature meter f.s.d. Transfer signal source to 180° output socket of OS103.3. Note reading on quadrature meter, and if necessary, re-adjust C72 for optimum, *i.e.*, one half of any amount that the meter may read with respect to zero.

With the mode selector at NORMAL and with a 1 kc/s signal input applied;

(*a*) to the 0° input socket with the 180° input socket earthed, and,

(*b*) to the 180° input socket with the 0° input

socket earthed, and with the appropriate amplitude.

VP253.3

Range:	150V	50V	15V	150 mV	50 mV
Input:	100V	40V	10V	100 mV	40 mV

check that the reference meter reads ±2% of f.s.d., and that the quadrature meter reads within ±1% of f.s.d.

Harmonic Rejection

Set up the test gear to provide a 4-phase reference signal of 10V at 80 c/s to the VP253.3. Connect the 0° input socket to the CO546 output, and switch VP253.3 to the 15V UNBALANCED range. Set CO546 to deliver a 10V signal, and synchronise the frequency to that of the OS103.3 within 0.1 c/s at 160 and 240 c/s. Check that both reference and quadrature meters read within ±0.1V of zero at both frequencies.

Self-Heating Error

Set up test gear using only the OS103.3 and VP253.3. Apply 4-phase input to VP253.3, of 10V amplitude and 80 c/s frequency, and monitor the OS103.3 output with the valve voltmeter (VF252).

Allow 30 minutes warm-up period, set OS103.3 output to precisely 10V, and note the reference meter reading. Leave test gear and VP253.3 in operation for 3 hours, and after ensuring that the OS103.3 output still stands at exactly 10V, check that the present reading on the reference meter is within 2% of the former reading.

The overload indicator is intended primarily to indicate an overload in the signal amplifier chain, which would not normally be indicated on the meters, such as an input with a high noise to signal ratio. In this case the meters would indicate only signal and the amplifier would be overloaded by noise. The CRO socket provides a means of monitoring to see the cause of the overload.

The overload indicator will, however, operate due to other causes such as excessive signal input and a positive change of D.C. voltage in sub-units 3 and 4. Still another reason for the indicator to operate could be a change of operating conditions or a change within a system under test. In this case, although the overload would be momentary, the overload circuit would reset and re-operate for some time due to the long recovery time of the VP253.3 circuit. Although the operation of the overload circuit does not change the circuitry of the amplifiers, any readings observed during an overload indicated period are not reliable and it is advisable not to continue tests for about one minute after the indicator has ceased to operate.

Failure of the overload circuit to operate on a known overload will be due to a fault in the overload circuitry and checks should be made of V11 and V12 and associated circuitry, particularly RLA/2 and its contacts.

FAULT LOCATION CHART

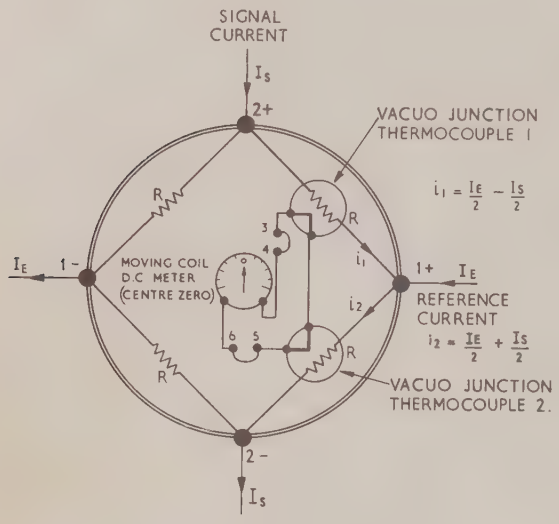
SYMPTOMS	POSSIBLE CAUSE	REMEDY
Complete failure.	Open circuit fuse. No A.C. supply voltage. Mains voltage transformer in power supply sub-unit faulty. Open circuit wiring from mains voltage input to mains transformer primary primary winding.	Change the fuse. Measure the A.C. supply voltage applied to mains transformer primary winding. Measure the continuity and insulation of the transformer primary winding.
No indication on the meters with the unit switched on and warm.	The meters will not normally indicate unless both signals and reference inputs of suitable amplitude are applied to the unit.	1. Ensure that a 4-phase reference signal is properly connected via the 4-phase cable. 2. Connect the 0° signal input socket to the 0° reference terminal. Switch the input attenuator to the 15 V range. 3. Measure the 300 V high tension supply. 4. Measure the 100 V low tension supply.

(continued overleaf)

SYMPTOMS	POSSIBLE CAUSE	REMEDY
		5. Monitor the signal at Test Point 8 on sub-unit No. 1. 6. Monitor the signal at Test Point 6 and 7. 7. Monitor the signal at Test Point 5. 8. Monitor the signal at Test Point 3. 9. Monitor the signal at Test Point 2.
No 300 V high tension from power supply sub-unit.	Faulty regulator or rectifier valves. Short circuit on the high tension line. Faulty mains transformer. Faulty component in the regulator circuitry.	Change the valves in the power supply sub-unit. Measure the high tension line for short circuits. Measure the voltage applied to the rectifier anodes. Check the circuitry components of the power supply sub-unit.
Incorrect 100 V low tension from sub-unit 2.	Short circuit on the 100 V line. Faulty valve in the sub-unit V12B, V13. Faulty component in the unit circuitry.	Check the 100 V line for short circuit. Change the valves. Adjust slight errors with RV12. Measure other circuit components and change if necessary.
Incorrect signal at Test Point 8 on any of sub-unit type 1.	Fault in the relevant sub-unit. Fault in the corresponding input cathode follower on sub-unit 9.	Check input cathode follower by monitoring the signal on pin B1 of the sub-unit in the faulty channel. Change the valve and check circuitry if the cathode follower is faulty. Change the valves in sub-unit 1 and check circuitry for faulty components if necessary. Re-check the D.C. potential on TP8 after any repairs to the sub-unit.
Incorrect signal at Test Point 6 and 7.	This will indicate a fault in the signal amplifier chain.	Continue monitoring signals at Test Points in the order specified.
Incorrect signal at either Test Point 6 or 7 with correct signs at Test Point 5.	This will indicate a fault in one of the output amplifiers.	Change the valves in the faulty sub-unit. Check the D.C. level at the relevant test point. Check circuit components and change if necessary. Check meter circuitry. Check the coupling circuitry between Test Point 5 and input of the faulty unit.
Incorrect signal at Test Point 5 with correct signal at Test Point 3.	This will indicate a fault in the main signal amplifier sub-unit 5.	Change the valves V41 and V42 in sub-unit 5. Check the D.C. voltage on Test Point 5. Check circuit components in sub-unit 5 and change if necessary. Check the coupling from Test Point 3 to the input of sub-unit 5.
Incorrect signal at Test Point 3 with correct signal at Test Point 2.	This will indicate a fault in sub-unit 7.	Change the valves V61 and V62. Check the DC voltages at Test Point 3. Check the circuit components of sub-unit 7 and change if necessary. Check the coaxial coupling between Test Point 2 and the input to sub-unit 7. Check switch 72/4F on sub-unit 8.
Incorrect signal at Test Point 2.	This will indicate a fault in sub-unit 8, V72, or input switching, SW71/3R.	Change V72 and check its circuit component. Check the input switching circuit.
The 180° signal input amplifier on sub-unit 8 and 6 can be checked in a similar manner to the 0° signal input amplifier using Test Points 1 and 4 instead of 2 and 3.		
Residual reading on either meter with no inputs.	Faulty meter. Faulty high tension supply.	Change the meter. Check the high tension supply for correct voltage and hum level.
NOTE: Before a new thermocouple meter is fitted it is recommended that the unit is checked for normal operation using dummy meters—see Fig. 15.		
Residual reading on both meters with reference input only.	Faulty signal channel output amplifier sub-unit 6 or 7.	Check sub-units as before for D.C. voltages on the relevant test point.
Large meter swing at 25-100 cycles per second operation.	High tension rectifier faulty.	Change the valve.

APPENDIX A

The deflection of the thermocouple wattmeters used in this instrument is directly proportional to the product of the reference input and the 'in phase' component of the signal input. The circuit of one of these meters is shown in Fig. 2. If the four resistor arms are equal, then the current in thermocouple 1 is $\frac{I_e}{2} - \frac{I_s}{2}$, and the current in thermocouple 2 is $\frac{I_e}{2} + \frac{I_s}{2}$.



The voltage elements of the thermocouples are in series opposition, and the voltage output of each is proportional to the square of the current in it. Thus the instantaneous voltage applied to the meter movement is proportional to

$$\left(\frac{i_e + i_s}{2}\right)^2 - \left(\frac{i_e - i_s}{2}\right)^2$$

or simplifying $2i_e . i_s$.

i.e. $K . i_e . i_s$.

Where K is an arbitrary constant.
Assume i_e is of the form A sin ωt
and i_s is of the form B sin pt.

Then the average meter deflection

$$= \frac{K}{t}\int_0^t A \text{ Sin } \omega t \text{ B Sin pt dt}$$

$$= \frac{KAB}{t}\int_0^t \tfrac{1}{2} \text{ Cos } (\omega - p)\, t - \tfrac{1}{2} \text{ Cos } (\omega + p)t \text{ dt}$$

There are three cases which require consideration:—

(a) when $p = w$ —
(b) when $p = nw$ — where ϕ is an arbitrary phase shift
(c) when $p = \frac{nw}{m}$ — n and m are arbitrary constants

In case (a):
The integral simplifies to:—

$$\frac{KAB}{2t} \text{ Cos } \phi - \text{Cos } (2wt - \phi)\, dt.$$

which expression contains a d.c. and a double-frequency term. This gives an average deflection over one cycle of:—

$$\frac{KAB}{2} \text{ Cos } \phi$$

Thus if the energising current $\left(\frac{KA}{2}\right)$ is constant, the deflection is proportional to the d.c. term (B Cos ϕ), being the component of the signal current which is in phase with the reference current. The double-frequency term is averaged to zero by the thermal inertia of the thermocouple, or at very low frequencies, by the integrating amplifier.

In case (b):
The integral becomes

$$\frac{KAB}{2t} \text{ Cos } (w - nw)\, t - \text{Cos } (w + nw)\, t\, dt = \text{a.c. terms only}$$

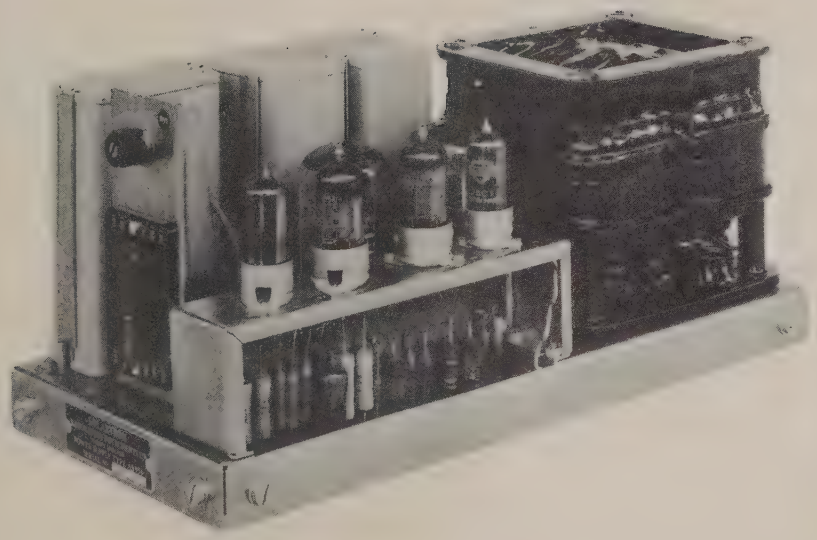
which gives an average deflection of zero over one cycle.
Thus, there is no deflection from any multiple (n) of the reference current which may be present in the signal current.

In case (c):
The integral becomes

$$\frac{KAB}{2t} \text{ Cos } \left(w - \frac{nw}{m}\right) t - \text{Cos } \left(w + \frac{nw}{m}\right) t\, dt = \text{a.c. terms only.}$$

There is now no direct harmonic relationship between w and p and it can be shown that, over an infinite period of time, the average value of the integral is zero, except in the special case where m=n.
In practice, when pt approaches wt so that they are less than about 3 c/s apart, the meter pointers will commence to 'beat' due to the lack of thermal inertia of the thermocouples. This beat can be reduced by switching in the integrating amplifier.

POWER SUPPLY SUB-UNIT
AS 956.2



SOLARTRON

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ber, 1964

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TECHNICAL MANUAL

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SECTION 1

INTRODUCTION

This electronically regulated HT Power Supply Sub-Unit has been developed by the Solartron Electronic Group to provide power supply units as components, rather than as bench instruments. Each unit is a carefully engineered entity, ready for immediate inclusion in a research or production instrument. It is also suited to the needs of educational establishments and radio and television servicing, where the small physical dimensions permit ease of use in congested work areas.

Both H.T. lines are isolated from earth so that the units may be used to give positive or negative outputs, and may be connected in series. Maximum reliability is ensured, even after long periods in store, by the elimination of electrolytic capacitors, and by using only the highest quality components. Each unit is mounted on a light, but rigid, sub-assembly frame provided with fixing points and angle brackets to permit fixing in any plane.

SECTION 2

OPERATING INSTRUCTIONS

1) Set mains input selector panel to the declared voltage of the mains supply.

2) Connect a voltmeter across the d.c. output terminals of the AS 956.2, and apply mains to power unit.

3) Adjust RV1 to obtain the required output voltage.

4) Switch off mains supply.

5) Connect power unit output and earth terminals to the equipment to be supplied.

   NOTE : A separate connector is provided for the screen of the mains transformer. This lead must be connected to the point giving minimum mains borne noise, usually mains earth.

6) The power unit is now ready for use. The d.c. output may be adjusted on load between 200-300 volts by means of the preset control RV1. All outputs are isolated and potentials not exceeding 500 volts peak may exist between the outputs and chassis.

SECTION 3

PERFORMANCE SPECIFICATION

D.C. Output Voltage :	± 200-300V continuously variable	Ripple and Noise Content :	< 2mV peak to peak.
D.C. Output Current :	0-200mA.	Permissible Supply Deviation :	± 7%
A.C. Outputs	: 6.3V 6A C.T. 6.3V 6A C.T. 6.3V 2A	Power Input :	100-125 / 200-250V 50-60 c/s or 400 c/s.

Stability factor	:>400:1	Overall Dimensions :	13.1/8" width x 6.15/16" depth x 5.15/16" height. (33.3 x 17.6 x 15.1cm)
Source Impedance (d.c. -250 Kc/s)	:<0.75Ω	Weight :	17¼ lb. (7.8 kg.)

SECTION 4

PRINCIPLES OF OPERATION

The circuit used in this power unit is composed of the following sections :-

1. Power Transformer.
2. Main h.t. rectifier.
3. Auxiliary h.t. rectifier.
4. 75V Stabilised Supply.
5. Stable Voltage Reference.
6. Feedback Network.
7. D.C. Amplifier.
8. Series Control Valves.

These are interconnected as shown in the block diagram (Fig. 1) on page 3.

A proportion of any change which appears on the stabilised output is fed through the feedback network nto the wide-band d.c. amplifier. It is then amplified and fed to the grids of the two parallel connected series control valves. This alters the volt drop across these valves in such a sense as to oppose the initial change. The final magnitude of the change is a function of the gain of the wide-band d.c. amplifier. The series control valves are pentode connected, in parallel with each other. Using pentode connection gives a high amplification factor and these valves can thus tolerate large ripple voltages at the anodes.

SECTION 5

CIRCUIT DESCRIPTION

The mains transformer is provided with a split primary winding capable of parallel on series connection to accommodate mains inputs of 100-125 or 200-250 volts. Seven secondary windings are provided.

1. Main HT : providing the 200V-300V supply to the load.
2. Auxiliary h.t., providing the anode potential and reference voltage to the d.c. amplifier.
3. 6.3V 3.2A : heater supply for the 12E14 series control valves, V1 and V2.
4. 6.3V 0.85A : heater supply for the d.c. amplifier valves V4 and V5.
5. 6.3V 2A : a.c. output.
6. 6.3V 6A : centre tapped, a.c. output.
7. 6.3V 6A : centre tapped, a.c. output.

The main h.t. supply is rectified by the bridge-connected silicon diodes MR5-MR8, C1 and C2 being the reservoir capacitors.

The auxiliary h.t. supply to the d.c. control amplifier is rectified by MR1-MR4 and stabilised at 75 volts by V3.

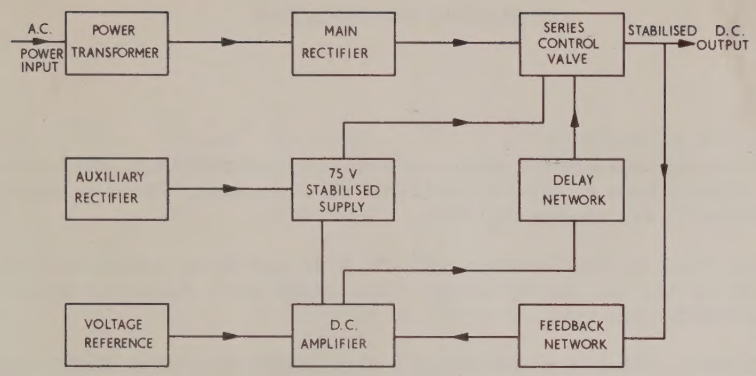

Fig. 1. Block Diagram.

To prevent voltage surges at the output terminals when the unit is initially switched on, or the mains supply is interrupted momentarily, a neon valve (V7) is connected in parallel with V4A. When the instrument is switched on, the neon conducts thereby holding V1 and V2 at cut-off point. This delays the HT potentials at V4 and V5, allowing these valves to warm up. When V4A draws enough current, a volt-drop is produced across the neon, causing it to cut-off and thereby allowing V1 and V2 to cut-on and deliver the HT voltage.

The 75V stabiliser is a 75C1 neon stabiliser (V3) connected between the positive output of the auxiliary rectifier and the stabilised main HT+ rail, which is common with the auxiliary negative. This source supplies the anodes of the pentode section of both ECF 80 valves (V4B and V5B), and the triode section of V4. The screens of the series control valves (V1 and V2) are also supplied from this source.

The voltage reference is a Mullard 85A2 (V6) operating at a current between 4 and 8 mA according to the output voltage setting. This valve has a burning voltage of 85 V.

The feedback network is a series of high-stability resistors RV1, R17 and R18, connected between the stabilised main HT+ and HT- lines. It acts as a potential divider supplying an error signal to the wide-band d. c. amplifier. RV1 permits adjustment of this potential between 200V and 300V.

The d. c. amplifier consists of two ECF 80 triode-pentode valves V4 and V5. The pentode sections (V4B and V5B) are connected as a cathode coupled differential amplifier and the triode sections (V4A and V5A) are similarly connected to form the second stage. The first stage of the amplifier compares the reference voltage with a portion of the HT voltage. The reference voltage developed across V6 is filtered by R22 and C6 against noise. The HT voltage is divided down in the feedback network. C5 connects directly from HT+ to the grid of V5B ensuring that there is no attenuation of ripple and noise frequencies. Under operating conditions the grid of V5B must be at virtually the same potential as the grid of V4B. Thus as the wiper of RV1 is moved, the HT potential must vary to maintain balanced conditions.

The push-pull output from this stage is directly coupled to the second stage, where further amplification takes place. The output from one side of the second stage (V4A) is fed via the stoppers R9 and R10 to the grids of the series control valves. First order correction of d. c. drifts due to heater fluctuations is obtained from the balancing action of the differential amplifiers. The heaters of both ECF 80 valves are returned to a d. c. potential derived from the V4A and V5A cathode resistor network R14 and R15, thus ensuring a low stress on the heater to cathode insulation.

The series control valves (V1 and V2) are connected in parallel, and between them carry the current drawn from the stabilised HT rail. The screens of these 12E14 valves are fed from the 75V stabilised supply through R7 and R8, and a control voltage from the d. c. amplifier is applied to the grids. C7 is connected across the HT output, and a 0.3 ohm resistor R4 is placed in series with the HT+ output to obviate unwanted phase shifts when the supply is applied to capacitive loads. The ferrox cube rings L1 and L2 in the anode circuits are provided as a precaution against self oscillation.

SECTION 6

SERVICING INFORMATION

erformance Tests.

1) Supply the unit with nominal mains, and correctly load all the a. c. and d. c. outputs. The voltage at the a. c. outlets should be ± 3% of nominal. The d. c. potential can be accurately set by adjusting RV1.

2) Monitor the d. c. stabilised line with a C. R. O. and check that the hum and noise present is less than that specified. The chassis and transformer screen should be earthed for this test.

3) Check that the changes of d. c. output are not measurable when the HT current is changed from the full load to zero, and when the mains input is varied ± 7% about normal.

4) The a. c. source impedance may be measured as follows :-

   Adjust the load current to 100 mA; feed the output of an oscillator through an 8μF capacitor and a 1K resistor in series into the output terminals of the power supply. The magnitude of the A. C. current must not exceed 200 mA peak to peak. Measure the a. c. voltage directly between the power supply output terminals $/Zo/ = \frac{V}{I}$.

5. Set the oscilloscope to 60 V/cm sensitivity range. Connect the output of AS 956.2 to input of CRO, and set CRO for d. c. input mode.

   Adjust mains to ±7% of nominal with use of Variac ; Switch the unit off for 20 seconds, and then re-apply mains. Measure the time delay between the appearance of output voltage. If necessary, adjust thermal delay to give a delay time of 10 seconds, and ensure that when mains is applied after a 20 second rest period, the output voltage does not increase above the rated output.

escent Potentials.

1) These potentials are supplied for information only and are not mandatory requirements. They were measured on an Avometer Model 8, with a loading of 200 mA at 300 volts, and a mains input of 240 volts.

Across C1, C2	-	490 V
Across C8 - C11	-	235 V
Across V3	-	75. 5 V
Across V6	-	85 V
Pin 6 of V4B to h. t. neg.	-	217 V
Pin 6 of V5B to h. t. neg.	-	217 V
Pin 1 of V4A to h. t. neg.	-	300 V

COMPONENTS LIST

RESISTORS

Circuit Ref.	Value Ohms	Tol. %	Rating Watts	Solartron Part No.	Manufacturer & Type	
R1	100	5	30	1857 21000	Painton	2001/B W.W. H.S.
R2	Not fitted					
R3	Not fitted					
R4	0.33	5		1602 00007	Solartron	S/S W.W.
R5	6800	5	4	1931 36800	Welwyn	F33 M.F.
R6	6800	5	4	1931 36800	Welwyn	F33 M.F.
R7	47	10	$\frac{1}{4}$	1723 14700	Erie	16 Carbon.
R8	47	10	$\frac{1}{4}$	1723 14700	Erie	16 Carbon.
R9	100	10	$\frac{1}{4}$	1723 21000	Erie	16 Carbon.
R10	100	10	$\frac{1}{4}$	1723 21000	Erie	16 Carbon.
R11	22	1	$\frac{1}{2}$	1707 12200	Painton	93 H S.
R12	22	1	$\frac{1}{2}$	1707 12200	Painton	93 H.S.
R13	47K	10	$\frac{1}{2}$	1725 44700	Erie	8 Carbon.
R14	12K	5	2	1930 41200	Welwyn	F32 M.F.
R15	22K	5	2	1930 42200	Welwyn	F32 M.F.
R16	Not fitted					
R17	36K	1	$\frac{1}{2}$	1707 43600	Painton	93 H.S.
R18	30K	1	$\frac{1}{4}$	1707 43000	Painton	93 H.S.
R19	68K	5	$\frac{1}{2}$	1708 46800	Painton	93 H.S.
R20	300K	5	$\frac{1}{2}$	1708 53000	Painton	93 H.S.
R21	300K	5	$\frac{1}{2}$	1708 53000	Painton	93 H.S.
R22	33K	10	$\frac{1}{4}$	1723 43300	Erie	16 Carbon
R23	12K	5	2	1930 41200	Welwyn	F75. OF
R24	15K	5	2	1930 41500	Welwyn	F75. OF
RV1	50K	10	$\frac{1}{2}$	1100 26120	Colvern	CLR 1106 W.W.

CAPACITORS

Circuit Ref.	Value µFd	Tol. %	Rating. Volts	Solartron Part No.	Manufacturer & Type	
C1	8	20	600		T.C.C.	CP150T Pa.
C2	8	20	600		T.C.C.	CP150T Pa.
C3	Not fitted					
C4	0.1	20	250		Hunts	AM102 M. Pl.
C5	0.25	20	250		Hunts	AM102 M. Pl.
C6	0.1	20	250		Hunts	AM102 M. Pl.
C7	8	20	600		T.C.C.	CP150T Pa.
C8	2	20	250		Hunts	AM106 M. Pl.
C9	2	20	250		Hunts	AM106 M. Pl.
C10	2	20	250		Hunts	AM106 M. Pl.
C11	2	20	250		Hunts	AM106 M. Pl.

INDUCTORS

Circuit Ref.	Description	Solartron Part No.	Manufacturer & Type	
L1	Ferrox cube	3090 10010	Mullard	FX 1242
L2	Ferrox cube	3090 10010	Mullard	FX 1242

SEMI-CONDUCTORS

MR1	Silicon Diode	3005 20080	Mullard	OA 210
MR2	Silicon Diode	3005 20080	Mullard	OA 210
MR3	Silicon Diode	3005 20080	Mullard	OA 210
MR4	Silicon Diode	3005 20080	Mullard	OA 210
MR5	Silicon Diode	3005 20090	Mullard	OA 211
MR6	Silicon Diode	3005 20090	Mullard	OA 211
MR7	Silicon Diode	3005 20090	Mullard	OA 211
MR8	Silicon Diode	3005 20090	Mullard	OA 211

VALVES

V1	Valve	3000 04060	Ediswan	12E14
V2	Valve	3000 04060	Ediswan	12E14
V3	Valve	3000 11080	Mullard	75C1
V4	Valve	3000 35020	Mullard	ECF80
V5	Valve	3000 35020	Mullard	ECF80
V6	Valve	3000 11020	Mullard	85A2
V7	Neon	3000 11101	Hivac	XC12T

MISCELLANEOUS.

X1	Thermal Cut-out		Belling & Lee	L422/1B/A
T1	Transformer	3011 50010		
MSP	Mains Selector Panel.	3990 00050		

Note : Equivalent components by other Manufacturers may be fitted in some instruments.

Abbreviations :

S.T.C.	Standard Telephones & Cables
T.C.C.	Telegraph Condenser Company
G.E.C.	General Electric Company
W.W.	Wire Wound
H.S.	High Stability
Pa.	Paper
Po.	Polystyrene
M.P.	Metalised Paper.
M.Pl.	Metalised Plastic
Ce	Ceramic
El.	Electrolytic
M.F.	Metal Film
O.F.	Oxide Film